SCIENCE ABSTRACTS.

Section A.—PHYSICS.

FEBRUARY 1924.

GENERAL PHYSICS.

177. *Registering Form of Balance.* **W. Braunbek.** (Zeits. Instrumentenk. 43. pp. 224–228, July, 1923.)—This form of balance consists of an arm rolling over a circular cylinder as shown in Fig. 1. The position of the beam, as measured by its angle of inclination with the horizontal for instance, gives the weight of the load W. Slipping is prevented by an arrangement of bands as shown in Fig. 2. The author gives a mathematical investigation of the sensitivity of the balance for various loads, and calculates the form of the roller which gives uniform sensitivity, *i.e.* a logarithmic scale. J. W. T. W.

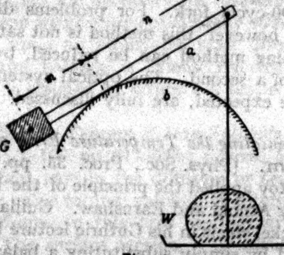


Fig. 1.

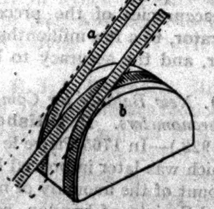


Fig. 2.

178. *Temperature of Maximum Density of Aqueous Solutions.* **A. Taffel.** (Faraday Soc., Trans. 19. pp. 99–104; Disc., 104–105, July, 1923.)—The decrease in the total volume occurring when 1 gramme of a substance is dissolved in water at a definite temperature to give a solution of a definite concentration is termed the "solution-contraction" for the substance at the given temperature and concentration. If the solution-contraction increases as the temperature at which dissolution is effected is lowered, then the temperature of maximum density of the solution is below 4°. If the reverse is the case, as happens with methyl, ethyl, and propyl alcohols, the temperature of maximum density will be above, at, or below 4°, according as the rate of decrease of the solution-contraction is greater, equal to, or less than the rate of thermal contraction of the solute. The organic non-electrolytes and also the phenols produce smaller molecular depressions of the temperature of maximum density than the binary electrolytes and the latter smaller than the ternary electrolytes; the sugars, however, give depressions close to those of the binary salts. The specific effect of ions and molecules in this depression is shown to be a result of their specific solution-contraction. T. H. P.

179. *Accurate Measurement of Short-Time Intervals.* **H. L. Curtis** and **R. C. Duncan.** (Bureau of Standards, Sci. Papers, No. 470. pp. 17–38, April, 1923.)—The method consists in producing simultaneously on a moving photographic film a record of the occurrence of the events under consideration and timing lines from a tuning fork acting as a shutter. This shutter consists of two opaque vanes, in which narrow slits have been cut, mounted on the prongs of a tuning fork, so that the slits are parallel to the axis of the fork, and coincide when the fork is at rest. When the fork vibrates the two slits will coincide twice during each complete period of the fork. The shutter is brilliantly illuminated, and the light which passes through as a flash when the shutter is opened is focused on the film by means of a suitable optical system. The accuracy depends on the accuracy of the tuning forks, of which there are three classes: (1) Self-driven forks; (2) forks driven by a master fork; (3) freely vibrating forks. These are all discussed. Very satisfactory results have been obtained by using a 100-cycle fork to drive a 500-cycle fork. For problems demanding the highest precision obtainable, however, this method is not satisfactory. The inaccuracies of the preceding method can be reduced, by using a comparator, to a few millionths of a second. The optical system, sources of error, and the accuracy to be expected, are fully discussed. T. C. H.

180. *New Balance for Compensating the Temperature Error of Watches and Chronometers.* **P. Ditisheim.** (Phys. Soc., Proc. 35. pp. 261–265, Aug., 1923.)—In 1765 Pierre le Roy applied the principle of the bimetallic rim which was later improved by Arnold and Earnshaw. Guillaume gave an account of the anomaly of nickel steels in his Guthrie lecture before the Physical Society of London, and by simply substituting a balance wheel with nickel-steel and brass bimetallic rim the Director of the International Bureau of Weights and Measures has solved the problem of the middle temperature (Dent's) error, but this balance can only be used with steel hair springs. An advance has now been achieved with hair springs made from Guillaume's new alloy "elinvar." The combination of this spring with the simple monometallic balance wheel is good enough now to fulfil the requirements of higher grade time-keepers. When the elinvar hair spring is made from a casting appropriate to a determinate linear expansion of the balance ring, very uniform rates over a wide range of temperature are obtained without need of adjustment by highly skilled timing watchmakers. The author gives details of the new balance and shows how it is a first attempt to reduce the barometric coefficient. The total absence of centrifugal force effect reduces the timing to the pure Phillips curves, thus facilitating the attainment of isochronism. The new form of compensation with the elinvar alloy is practically non-magnetic and rustless [see also Abstract 1118 (1920)]. T. C. H.

181. *Saybolt Viscosity Measurements and their Control.* **P. E. Klopsteg** and **W. H. Stannard.** (Indust. and Engin. Chem. 15. pp. 702–707, July, 1923.)—Particulars are given of the construction of a thermostatic bath and regulator designed more especially to conform with the requirements of the American Society for Testing Materials in the matter of temperature control for purposes of measuring the viscosities of lubricating oils by means of the Saybolt viscometer. The vessel containing the bath liquid is made narrow so as to secure two-dimensional circulation of the latter, and its bottom corners are rounded off. A regulator, of the de Khotinsky type, made of thermostatic metal is employed. The heating current is interrupted periodically by a separate mechanism, the thermally controlled contact closing the circuit on the cylindrical surface of a rotating disc. The setting of the contact from the " on " to the " off " position or vice versa is definitely effected by a change of 0·03° C. Stirring is produced by a screw of thin metal slipped over the lower end of the thermometer which is caused to rotate. J. S. G. T.

182. *The Surface Tension Balance.* **R. G. Green.** (Indust. and Engin. Chem. 15. pp. 1024–1025, Oct., 1923.)—In this paper a new type of surface tension balance is described for rapid measurement purposes, while affording standard values of reasonable accuracy. The drop weight method has been utilised, since corrections for standard values can be made thereby so small as to be negligible, and, in the procedure adopted, less than 5 drops of liquid are necessary for measurement. No calculations are used and the drop weights are not actually determined, the surface tension being indicated upon an adjustable scale directly in dynes per cm. Searle's torsion wire balance is briefly referred to [see Abstract 818 (1914)]. Accuracy is claimed to within 1–2 tenths of a dyne. H. H. Ho.

183. *Surface Tension of Iron Sulphide.* **E. J. L. Holman.** (Iron and Steel Inst., J. 107. pp. 517–522 ; Corres., 523, 1923.)—Surface tension plays an important part in the diffusion or segregation of sulphur in iron and steel. Its value for iron sulphide is determined by the method of measurement of drops—in this case castings of 800 grammes on a warm iron surface. The surface tension T is calculated from $T = gdh^2/4$, where h is the thickness of the casting and d its density, and a value 494 dynes/cm. was found for iron sulphide. For comparison, the measurement was also made in the cases of tin (462), lead (375), zinc (635), copper (940), and aluminium (477) and these values are tabulated with those found by Quincke and others. [See also Abstracts 1319 (1917) and 1253 (1919).] G. E. A.

184. *Angle of Contact between Paraffin Wax and Water.* **R. Ablett.** (Phil. Mag. 46. pp. 244–256, Aug., 1923.)—A special apparatus is devised in order to afford a more accurate method of determining the contact angle. The method consists essentially in immersing a cylinder, coated with wax, with its axis horizontal, to such a depth that the free liquid surface is plane right up to the line of contact with the curved surface of the cylinder. Readings are taken with the cylinder stationary and in rotation. Experimental details and precautions to obtain purity and accuracy are given in detail. The mean value of the angle of contact at 10° C. with the cylinder stationary is 104° 34′. The results obtained with the cylinder rotating are discussed in relation to the condition of a rising or falling meniscus. A note on the precise signification of the term "wetting" is added. A. B. C. L.

185. *Structure of Thin Films. Parts IV and V.* **N. K. Adam.** (Roy. Soc., Proc. 103. pp. 676–686 and pp. 687–695, July 2, 1923.)—Benzene derivatives, such as hexadecyl phenol, containing one long chain and one polar group in the para position orient on water surfaces like fatty acids, the phenol group forming the head of the molecule in contact with the water. Measurements of the cross-section of the head give a result in good agreement with the corresponding cross-section of the nuclei of aromatic compounds, deduced from Bragg's measurements on crystals. The relation between the films on water and the monomolecular layer which would be obtained by repeated cleavage of the crystal is studied and explained. Films of these compounds show the usual phenomena of expansion analogously to a two-dimensional vapour as previously described [see Abstracts 6 and 390 (1923)]. Compounds such as cetyl palmitate, palmitic anilide, etc., which contain one polar group placed between two chains, or one chain and a ring, do not adhere to a water surface well enough to give measurable condensed films, though in the expanded state such films are often more stable.

Bromine in the α-position in the bromo-acids and esters increases the cross-section of the molecules in the films. It lowers the temperature of change from condensed to expanded films, but does not appreciably affect the properties of the films when expanded. The double linkage in the $\alpha\beta$-position relative to the $COOC_2H_5$ group increases the cross-section of the molecules in the films, as is also found with iso-oleïc acid. The transition between two forms of condensed film, such as those found with the substituted ureas, seems exactly analogous to that between two polymorphs or allotropic modifications of solid substances. The law governing the increase of the temperature of expansion of the films with increasing length of the hydrocarbon chains is confirmed in eight homologous series. A. B. C. L.

186. *Isothermal Compression and Expansion of "Superficial Solutions" (Monomolecular Layers of Oleïc Acid on the Surface of Water).* **A. Marcelin.** (Comptes Rendus, 177. pp. 41–43, July 2, 1923.)—Two arrangements of apparatus are described, one of which is suitable for measuring tensions between 0·5 and 40 dynes-cm., the other being of great sensibility and capable of measuring up to 1/1000 dyne-cm. The saturation pressure for oleïc acid is given at 40 dynes-cm. and is found to remain constant in the presence of droplets under all circumstances of compression and expansion. In the absence of droplets the pressure diminishes rapidly, falling from 40 dynes-cm. in 1 minute, and 15 dynes-cm. in 5 minutes, this effect being attributed to the imperfect insolubility of oleïc acid in water. A. B. C. L.

187. *Bath Temperatures of Viscometers of the Saybolt Type.* **W. H. Herschel.** (Indust. and Engin. Chem. 15. pp. 945–946, Sept., 1923.)—It is pointed out that, in order to obtain consistent results, standard temperatures should be adopted for the Saybolt viscometer bath. Times of flow thus obtained cannot be used to calculate absolute viscosities at the nominal temperature of test unless allowance is made for the difference between that temperature and the average temperature of oil in the outlet tube during the run. The variation of temperature in the oil tube may be observed, in the Universal and Furol (U. and F.) viscometer, from readings of a thermometer kept in the oil tube during the run, and the average oil-tube temperature may be used in calculating correction factors for obtaining the absolute viscosity at the nominal temperature of test. The U. and F. viscometer is briefly described and illustrated diagrammatically. By changing the outlet tube, the instrument may be used either as a Saybolt Universal or as a Saybolt Furol viscometer. A. B. C. L.

188. *A Relation between the Viscosity of a Liquid and its Coefficient of Expansion.* **D. B. Macleod.** (Faraday Soc., Trans. 19. pp. 6–16; Disc., 34–37, July, 1923.)—In the case of homologous series of carbon compounds it is found that the viscosity in general rises with the higher members and the temperature coefficient of expansion falls. It is considered that the observed relations can be explained on the assumption that the viscosity is due to two factors, one of which depends on the molecule itself, and, in the case of normal unassociated liquids, may be assumed to be independent of the temperature, while the second factor is a simple function of the space within the liquid in which the molecules are free to move. If η_t be the viscosity of a liquid, and x_t the volume of the free space associated with a definite volume of molecules at any temperature t, it is found that the relation $\eta_t x_t^A$ = const. is closely followed. With normal liquids the value of A is approximately unity, or the viscosity is inversely proportional to the free space. In accordance with this view the value of the viscosity at a temperature t° C, relatively to the value at 0° C. is given by the expression:

$$\frac{\eta_0}{\eta_t} = \left(\frac{x_0 + \alpha t + \beta t^2 + \gamma t^3}{x_0}\right)^A$$

which involves two unknowns x and A. By a method of approximations, suitable values are given to x to make A have the same value at different temperatures. A better agreement with known data is given by this relation than in the case of earlier formulæ.

The observed increase in viscosity with rise of molecular weight in a homologous series is thus explained by the diminution of free space on ascending the series. This view is supported by a consideration of the densities of homologues on the assumption that the mean atomic spacing remains the same. The value of x is found to be greater for iso compounds, which is in agreement with their lower density. In the case of fatty acids and alcohols, especially, the value of A is considerably greater than unity, being as high as 3·4 in the case of iso-butyl alcohol. Liquids which give high values of A belong to a class of substances whose molecules are known to be associated at ordinary temperatures. This association attains its highest value in the case of colloids. It is probable that the association tends to break up at higher temperatures.

A similar relation to the above is obtained with gases at pressures where Boyle's law ceases to hold, when the viscosity is no longer independent of the pressure. It is shown from available data in the case of carbon bisulphide that with liquids under pressure an increasing rate of rise of viscosity occurs with rise of pressure, as is expected from the theory. Further, the estimated value of the free space is—as required by van der

Waals' theory—similar for different liquids at their boiling-points and is of the order required by that theory, the values for x at these temperatures being of the order of from 0·19 to 0·21 [see Abstract 1723 (1908)].

J. N. P.

189. *The Viscosity of Liquid Mixtures Showing Maxima.* **D. B. Macleod.** (Faraday Soc., Trans. 19. pp. 17–34; Disc. 34–37, July, 1923.)—From a consideration of the changes of free space, it is deduced that in cases of mixtures of liquids of widely-differing viscosities, the resultant viscosity is not the mean of the two viscosities, but lies on a sagged curve. This relation is borne out by such mixtures as glycerine-water and sulphuric acid and water.

The marked increase of viscosity which generally occurs on mixing liquids of approximately the same viscosity is attributed mainly to the increase of density which in turn is due to the chemical affinity between the constituents. This effect is analogous to the contraction and the accompanying increase of viscosity which occurs on cooling. It is probable that complexes which are formed further reduce the free space and consequently increase the viscosity. The most marked maximum is observed with mixtures of aniline and acetic acid.

These two factors can both be covered approximately by an equation of the type:

$$\eta = \eta_v\left(\frac{x}{x - C}\right)^{A_1v_1 + A_2v_2}.$$

where x represents the free space of the mixture per c.c. of volume before contraction, and C the contraction per unit volume; A_1, A_2 are constants for each constituent; v_1, v_2 the percentage composition, and:

$$\eta_v = \eta_1v_1 + \eta_2v_2$$

[See Abstracts 2747 (1904), 1602 (1907), 1723 and 2056 (1908).]

J. N. P.

190. *A Relation between Surface Tension and Density.* **D. B. Macleod.** (Faraday Soc., Trans. 19. pp. 38–41; Disc., 41–42, July, 1923.)—An empirical relation between surface tension and densities of a liquid at different temperatures ranging from the melting-point to the critical temperature, which has been found to agree closely with experimental figures, is of the form $\gamma/(\sigma_l - \sigma_v)^4 = C$ where C is a constant for each liquid, γ the surface tension at any temperature, and σ_l and σ_v the densities of the liquid and the vapour at the same temperature. This relation is in accordance with van der Waals' equation in which it is assumed that the force of attraction between the molecules diminishes as the fourth power of the distance between the molecules. The agreement in the case of associated substances, such as alcohol and acetic acid, is less satisfactory. The specific cohesion of a liquid, a^2, which is measured by the height to which a liquid rises in a capillary tube of unit radius, bears a relation to γ which is expressed as follows: $a^2 = 2\gamma/(\sigma_l - \sigma_v)$, whence $a^2 = 2C(\sigma_l - \sigma_v)^3$, or the specific cohesion of a liquid at various temperatures is proportional to the cube of the density difference. J. N. P.

191. *The Coefficient of Viscosity of Helium and the Coefficients of Slip of Helium and Oxygen by the Constant Deflection Method.* **M. N. States.**

(Phys. Rev. 21. pp. 662–671, June, 1923.)—The recent work of Stacy and van Dyke [see Abstracts 1716 and 2059 (1923)] on the coefficients of slip of air and carbon dioxide showed clearly that these quantities depend upon the nature of the bounding surfaces. The coefficient of slip was larger for the smoother surfaces, indicating that these reflected a greater number of molecules specularly. The present paper extends this work to different surfaces and gases. In addition, the chemical composition of the surface used afforded an excellent opportunity for studying the " time-effect " on the slip, while the coefficient of viscosity of helium was also determined. The constant deflection method was used, the apparatus being that with which Gilchrist and Harrington determined the absolute value of the coefficient of viscosity of air. Improvements in this apparatus are fully described together with the experimental procedure adopted. Using carefully purified helium, which showed only a spectroscopic trace of hydrogen, 6 series of measurements at about 23° C. gave $\eta_{23} = 1962 \cdot 3(10)^{-7}$. This is about 2 % less than values obtained by the capillary method, but is believed correct to within 0·1 %. The coefficients of slip of helium and oxygen for polished and unpolished silver oxide surfaces were determined, and the values obtained for $\zeta_{76}\ (10)^7$ are: for the unpolished surface, 123 (He), 61·1(O); for the polished surface, 160 (He), 64·5 (O). These are probably accurate to 1 %. From Maxwell's equation, the values for complete diffuse reflection, which are the minimum values, are computed to be 191 (He) and 70 (O). The low experimental values suggest a " reverse-specular " reflection; or, perhaps the abnormal momentum transfer at the surface may be attributed to an excess of molecules leaving the cylinders due to the release of oxygen at low pressures. The change of the slip with time, observed in previous work, is shown to be due to the release of occluded gases, chiefly oxygen in the case of a silver oxide surface. H. H. Ho.

192. *Variation of Pressure with Depth in Columns of Powders.* **J. H. Shaxby** and **J. C. Evans.** (Faraday Soc., Trans. 19. pp. 60–72; Disc., 86–89, July, 1923.)—It was shown by C. E. S. Phillips experimentally that a downward force applied to the top of a column of sand is not transmitted to the bottom if the column is more than a few diameters high. Assuming that the powder behaves to some extent like a liquid with a definite coefficient of friction with the wall of the containing tube, it is possible to represent the facts mathematically in the form:

$$p = \frac{\rho g R}{2c} + \left(P - \frac{\rho g R}{2c}\right)\epsilon^{-\frac{2cx}{R}}$$

or, in the absence of external pressure:

$$p = \frac{\rho g R}{2c}\left(1 - \epsilon^{-\frac{2cx}{R}}\right) \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

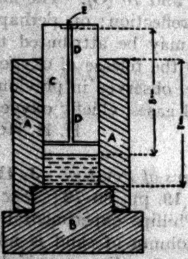
where p is the vertical pressure at a depth x below the free (horizontal) surface of the powder contained in a vertical cylindrical vessel of radius R; ρ the mas per unit volume of the powder in the given state; c a constant given by the equation $cp = \mu p'$ where p' is the horizontal pressure at the depth x; μ is a coefficient of friction and P is the external pressure applied vertically downwards at $x = 0$. Pressure is a function not only of the depth but also of the state of packing. For experimental work equation (1) can be written in the form:

$$p = p_m(1 - \epsilon^{-kx}) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

where $p_m(=\rho g\mathrm{R}/2c)$ is the maximum pressure and $k(=\rho g/p_m)$ is a constant. If the surfaces of equal pressure are conical instead of plane, the equation for average pressure p_a is given by:

$$p_a = p_m(1 - \mathrm{C}\epsilon^{-kx}) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

where C and k are constants. Three methods of measuring the pressure are described. The first proved unsatisfactory. A table of results of the second method is given, equation (3) fitting the corresponding experimental curve well. The third method and the four sections of experiments in connection with it are described very fully. Curves and tables of results are given. Measurement of the average vertical pressure p_a at various depths x in columns of lead shot and powder indicate an exponential increase of p with x. The general form of the pressure-depth curves agrees well with equation (3). T. C. H.



193. *Properties of Powders. Part VI. Compressibility of Powders.* **E. E. Walker.** (Faraday Soc., Trans. 19. pp. 73–82; Disc., 86–89, July, 1923.)—The author treats of the compression of powders by static loads and by impact. The figure gives a sectional elevation of the container in which the powders were compressed. The hard tool steel plunger C is an easy working fit in the cylinder AA. Narrow grooves DD are cut on it to facilitate the escape of air. The volume of the powder is expressed by the ratio:

$$\frac{\text{observed volume of powder}}{\text{theoretical volume of solid particles}}$$

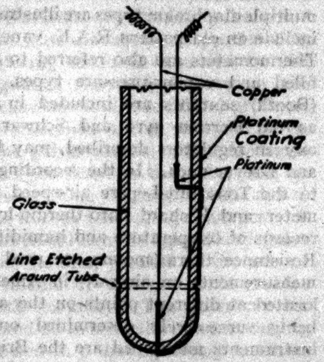
referred to as the *volume ratio* and represented by the symbol V. If M = mass of drop weight and m = mass of plunger (both in kilograms); h = height of drop (cm.); V = velocity of impact (cm. per sec.); W = work done on powder (kilogram cm.); R = resistance to compression (kilograms/sq. cm.); V_1 and V_2 = volume ratio before and after blow, respectively, and Q = quantity of power taken (expressed as cubic cm. of solid), we get:

$$\mathrm{R} = \frac{\mathrm{M}h\left(1 - \dfrac{(1 - k^2)m}{\mathrm{M} + m}\right)}{\mathrm{Q}(\mathrm{V}_1 - \mathrm{V}_2) + \mathrm{C}v}$$

Experiments indicate that, using velocities of impact between 173 cm./sec. and 488 cm./sec., C = 0·001 and k = 0·6. Curves and tables give results of experiments on powders made from several different materials [see Abstract 570 (1923)]. T. C. H.

194. *Properties of Powders. Part VII. Distribution of Densities in Columns of Compressed Powder.* **E. E. Walker.** (Faraday Soc., Trans. 19. pp. 83–86; Disc., 86–89, July, 1923).—When a powder is pressed into a cylinder by a plunger, the density of the powder is not evenly distributed, but is greatest immediately beneath the plunger, gradually falling off as the distance from the plunger increases. A long sectioned container 2·28 cm. in diameter was employed to examine this density gradient experimentally. The results are recorded graphically by means of curves, the volume ratios (that is the ratio of the apparent volume of powder to the actual volume of particles) being plotted as ordinates and the distance of the layer from the surface immediately beneath the plunger as abscissæ. The curves are straight over the greater part of their length. As the volume ratio approaches 1·0, the curves obviously become horizontal, as there can be no density gradient in the solid material. From results obtained it is seen that in the equation for the part of the curves which is a straight line, $V = C + ml$, where V = volume ratio of the thin layer 1 cm. from the surface at which compression takes place, the gradient constant m is roughly proportional to the fourth root of the cross-sectional area. From the curves the distribution of pressure in a column of compressed powder is deduced. T. C. H.

195. *Detector for Water-Vapour in Closed Pipes.* **E. R. Weaver** and **P. G. Ledig.** (Indust. and Engin. Chem. 15. pp. 931–934, Sept., 1923.)—This apparatus for determining the approximate concentration of water-vapour in a gas consists of a piece of straight glass tubing sealed at one end. Near the closed end two platinum wires are sealed through the glass and fused against the outer surface of the tube, which is then frosted with a paste of barium sulphate and ammonium fluoride. The ends of the platinum wire inside the tube are soldered to copper leads, the outside of the cell being carefully platinised. The tube is then coated with paraffin and a line etched round it with hydrofluoric acid to break the continuity of the platinum surface; the separation surface and the platinised electrode surfaces being painted with a dilute solution of some hygroscopic electrolyte. The tube itself is filled with melted paraffin, which is allowed to solidify and the apparatus is mounted in any suitable manner. The resistance to an alternating current of the film bridging the "scratch" between the electrodes is a measure of the concentration of water-vapour present. Sulphuric and phosphoric acids and various hygroscopic salts can be used in forming the conducting film. The authors describe the laboratory experiments, the method of application, and the limitations of the device. The figure gives a general idea of the detector. [See also Abstract 2 (1921).] T. C. H.



196. *Aeronautic Instruments.* **F. L. Hunt.** (Bureau of Standards, Technol. Papers No 237. pp 447–511, Washington, 1923).—The object of this paper is to describe the various types of aircraft instruments in actual use in different countries, with special reference, however, to American practice. A definite grouping of the instruments is adopted, as follows: Altitude, Speed, Orientation Engine, Navigating and Special Instruments, including oxygen, recording, strut and gas temperature thermometers, timepieces, and manometers and hydrogen leak detectors. In the first group, altimeters, barographs and statoscopes are described briefly. Among the air-speed instruments dealt with, may be mentioned the Foxboro and Bristol double bellows, and double diaphragm types, respectively, the Pensuti pressure-plate and the Morell-cup anemometer indicators. Hot wire and propeller type air-speed indicators are referred to also. The Bureau of Standards rate-of-climb indicator with single diaphragm, on the capillary leak principle is described. In connection with compasses, one resembling the well-known Creagh Osborne 5/17 type, and termed the General Electric inclined card compass is described. The Sperry combined horizontal and vertical compass used in the American air services is also described. Reference is made also to the Sperry air-driven and the Drexler electric gyro-turn indicators. Amongst the inclinometers described may be noted the Sperry air-damped pendulum lateral, and liquid damped pendulum fore-and-aft inclinometers. Various types of centrifugal, chronometric and magnetic revolution indicators are described.

The float-type, and hydrostatic-pressure type of petrol depth gauges are both dealt with, and several original differential pressure single and multiple diaphragm types are illustrated. The petrol flowmeters mentioned include an old pattern R.A.E. vane, and an American slit-tube float, type. Thermometers are also referred to and descriptions given of both liquid-filled and vapour-pressure types. The Byrd bubble, and the R.A.E. (Booth) sextants are included in the navigation instruments, as well as the Derrien gyro and Schwarzschild bubble types. Amongst the oxygen regulators described, may be mentioned the van Sicklen-Prouty and Dreyer ones. In the recording instrument section reference is made to the Toussaint-Lepère air-speed recorder, the Bristol recording tachometer, and Richard baro-thermo-hydrograph (an instrument which gives records of temperature and humidity, in addition to barometic pressure). Resistance thermometers are used for gas and atmosphere temperature measurements on aircraft, in America; several resistance elements are located at different points on the aircraft, the temperature of each point being successively determined on an indicator. Among the airship instruments mentioned are the British water-ballast gauge, Pioneer gas-pressure metallic manometer, and Davis hydrogen leak detector. Most of the instruments described or referred to are illustrated in the 58 excellent photographic reproductions included. A. W. J.

197. *The Determination of the Altitude of Aircraft.* **W. G. Brombacher.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 719–774, Sept., 1923).—This is a fairly complete account of the general principles of height determination and of the practical methods which are being made to afford a satisfactory solution of the problem. The need for a method of accurate determination of altitude, from the aircraft itself, for aerial photographic survey, navigation, performance tests, and for bombing is emphasised. Referring to the use of correctly calibrated altimeters, with small errors, the author states that those in use are pressure measuring instruments, whereas a coordination of both pressure and temperature is essential. Further, if an altimeter be calibrated to an altitude-pressure relation which includes one of altitude-temperature based on means of observations, the indications of the altimeter may be in error by as much as 5 per cent., due to annual temperature variations from the mean values. It is considered essential that both pressure and temperature be observed for altitude determination, and the following relation is arrived at:

$$h = 62900 \log \frac{P_0}{P}\left(1 + \frac{t_m - 10}{283}\right)$$

where h is the height in feet, P_0 is the atmospheric pressure at ground level, P is the pressure at the upper level, and t_m is the mean temperature centigrade, of vertical column of air between the levels. A more complete expression for the altitude is also derived in which factors of slight practical importance, such as gravity and moisture, are included. The observations of pressure and temperature necessary to determine an altitude are discussed, and the instruments used to make these observations described, briefly. The method of computation of the altitude from these observations is outlined and a sample computation is given by way of example. The paper concludes with sixteen tables of upper air data, aircraft performance standards and altimeter calibration standards for the United States and other countries. A. W. J.

198. *Self-Registering Apparatus for Automatically Recording Ionisation and other Curves.* **P. Knipping.** (Zeits. Instrumentenk. 43. pp. 241–256, Aug., 1923.)—The photographic registering drum is mounted on the same shaft as the switch, which regulates the voltage between the incandescent kathode and the grid, accelerates the electrons, and produces the velocity which ionises or excites the molecules of the gas under investigation. Light from the mirror of the galvanometer, which measures the ionisation current, or other current produced in the tube, falls on the photographic film, the deflections being along the length of the drum, or at right angles to the displacements due to the voltage changes. A device is employed in which a small additional lamp is lighted at regular intervals, and prints a series of lines on the film, parallel to the axis of rotation, corresponding to equal increments of voltage. This enables the curves taken to be measured with accuracy. The galvanometer lamp can be automatically switched on and off in a regular manner during a run; so that the line recorded is dotted in a distinguishing manner, and a number of curves may be taken on the same film, and easily identified. It is possible to shift the apparatus parallel to the axis, so that the different curves taken are separated from one another. The shaft can be driven at constant speed, which can be varied within large limits, by means of a special motor, and special switching arrangements were made so that measurements could be carried out in the darkened room, which could only be lighted by means of a red lamp, which did not affect the photographic film. The following investigations have been carried out with this apparatus: ionisation and excitation of light in helium and in hydrogen (not as yet completed); ionisation of the halogen compounds of hydrogen, and of complicated compounds such as acetic acid; these last have as yet given no definite values, but show the enormous influence of small quantities of water-vapour; ionisation of water-vapour (incomplete); exit work of the electrons from different incandescent wires. H. N. A.

199. *Effect of the Rolling of a Ship on the Readings of a Marine Mercury Barometer.* **M. A. Giblett.** (Phil. Mag. 46. pp. 707–716, Oct., 1923.)—A comparison at sea, between the readings of a marine mercury barometer and an aneroid, suggests that at times there may be a persistent depression of the mercury in the former without pumping; this may be due to the forced oscillations of the barometer caused by the rolling of the ship. If the angle of roll is small, periodic motion of the point of support of the barometer gives the instrument a free oscillation superimposed on a forced oscillation. The equation for the motion of the mercury, due only to the forced oscillation, is deduced; this shows that the mercury oscillates about a mean height usually less than the true height. Curves are included from which the depression of the mercury may be determined, given the period of the forced oscillation and the displacement of the point of support of the barometer. The oscillations of the mercury are generally less than 0·25 mb., and in many cases negligible. A. W. L.

200. *Friction of Pivotal Movements.* **A. Jaquerod, L. Defossez,** and **H. Mugeli.** (Arch. des Sciences, 5. pp. 305–309, July–Aug., 1923.)—A description of researches made with very small pivots (0·9 mm. diameter) working between jewels, such as used in watch-making. Taking the case where the spindle is horizontal, it was found, after studying the influence of speed of rotation, that the results presented the same general character as those of Stribeck (working on spindles several cm. in diameter), who interprets the hydrodynamic theory of Sommerfeld. The coefficient of friction diminishes rapidly at first as the speed increases, passes a known minimum, then immediately increases indefinitely. The viscosity of the lubricant plays a most important part. The results are represented empirically by the equation:

$$f = f_0 e^{-\lambda\omega} + A\omega$$

where f is the coefficient of friction, ω the angular velocity, and f_0, λ, and A constants depending on the bodies in contact. T. C. H.

201. *Engineering Problems Solved by Photoelastic Methods.* **E. G. Coker.** (Frank. Inst., J. 196. pp. 433–476, Oct., 1923. Two lectures delivered at the Royal Institution of Great Britain, May, 1923.)

202. *The Value of the Energy Relation in the Testing of Ferrous Metals at Varying Ranges of Stress, and at Intermediate and High Temperatures.* **T. M. Jasper.** (Phil. Mag. 46. pp. 609–627, Oct., 1923.)—Complete information as to the static, elastic, and fatigue properties of metals at high temperatures is desired by the designers of steam turbines and high-speed internal combustion engines. Goodman's diagram showing the relation between the range of stress allowable and the maximum stress has been checked for a considerable range by the investigators working on the fatigue of metals at the University of Illinois, but with heat-treated steels the agreement ceases to be good. Investigations of the energy relation have shown that this is applicable to fatigue testing at ordinary temperatures, and to static testing at high temperatures, and suggest its application to fatigue testing at high temperatures. At ordinary temperatures it is found that the energy per unit volume absorbed by the most stressed portion of the material is very nearly constant. Using this fact, a diagram showing the maximum allowable range of stress, on a base representing the ratio of maximum to minimum stress, has been constructed, and is given in the paper. To use this method at high temperatures a knowledge of the moduli of elasticity as functions of temperature is required. It is shown that Sutherland's relations hold, in the case of ferrous metals, up to 950° C., but Young's modulus falls off so much in that neighbourhood as to suggest an as yet undiscovered "critical" point. In the appendix it is suggested that the use of the energy relation at high temperatures is limited to those below that at which the steel was quenched. Reference is also made to some results obtained at the University of Illinois, showing that the energy per unit volume absorbed in stressing to the yield point in tension tests is constant for temperatures up to 950° C. W. G. B.

203. *Elasticity of Metals as Affected by Temperature.* **C. Schaefer.** (Zeits. f. Physik, 17. 2. pp. 152–154, 1923.)—It had been stated by A. Mallock [see Abstract 666 (1919)] that there had been no systematic investigation of the temperature variation of the elastic constants, though there had been a few measures of the kind made in Switzerland and America. The present author here points out that such investigations have been made in Germany, *viz.* (1) by Katzenelsohn in 1887 and (2) by himself in 1900–1901 [see Abstract 2377 (1900)]. These two investigations are in good agreement, and the author considers the results of A. Mallock to be of a less accurate character. A comparison of the English and German work is given in the table.

Material.	Melting-Point.	Percentage of Elastic Modulus for 100° C.	
		A. Mallock.	C. Schaefer.
	°C.		
Pt	1765	1	0·73
Pd	1542	1	1·98
Fe	1500	1	2·25
Ni	1452	4	2·46
Au	1070	11	—
Cu	1082	13	3·63
Ag	970	13	7·65
Al	645	16	21·32
Zn	619	36·6	—
Pb	327	29	—

E. H. B.

204. *Time Law of the Inelastic Deformation of Zinc and Iron.* **O. Brezina.** (Phys. Zeits. 24. pp. 338–344, Aug. 15, 1923.)—The effect of time on the deformation of zinc and iron was investigated, and the results discussed mathematically. The paper does not lend itself to abstracting. F. J. B.

205. *Coefficient of Rigidity and Young's Modulus for Selenium Crystals.* **L. P. Sieg** and **R. F. Miller.** (Iowa Acad. Sci., Proc. 28. pp. 103–111, 1921.)—Elastic constants determined from drawn wire are not so much characteristic of the substance itself as of the particular physical state of the substance. The employment of an isolated crystal of a simple elementary substance should, however, enable determinations to be made of the elastic constants of the substance itself. The authors describe experiments which they have made upon crystals of selenium with the object of determining Young's modulus and the coefficient of simple rigidity. The crystals were in the form of slender hexagonal prisms, and in determining Young's modulus the method of bending was employed, all measurements being observed with a travelling microscope. For the determination of the coefficient of rigidity, observations were made of the period of vibration of a torsion pendulum using the crystal as the support. The results of a number of experiments give a mean value for Young's modulus $Y = 5 \cdot 40 \times 10^{11}$ dynes per cm.^{2} showing an elasticity about one-third that of steel. The mean value obtained for the coefficient of rigidity was $n = 0 \cdot 65 \times 10^{11}$ dynes per cm.^{2}. The ratio Y/n is equal to $8 \cdot 3$ which is unusually high as compared with isotropic substances.

L. F. M.

206. *The Theory of Bending.* **W. Hovgaard.** (Inst. Naval Architects, Trans. 65. pp. 339–347 ; Disc., 348–349, 1923.)—A proof, based on the "Principle of Least Work," of the essential correctness of the usual procedure in dealing with the bending of composite beams, *i.e.* that the strain is proportional to the distance from the neutral axis. Examples of the application to semi-rigid airships, and to reinforced concrete beams are given. For mathematical details the paper must be consulted.

W. G. B.

207. *On Eddies in Air.* **H. Nisi** and **A. W. Porter.** (Phil. Mag. 46. pp. 754–768, Nov., 1923.)—The relation between the critical velocity, *i.e.* that at which eddies commenced to form, and the dimensions of the obstacle and the wind-channel for spheres, cylinders, and plates was obtained by the usual methods. For spheres and cylinders, the value of the Reynolds number corresponding to the critical velocity was found to be given by the formula:

$$A_1 + A_2\left(\frac{d}{D}\right)^n \quad \left\{\begin{matrix} d = \text{diam. of obstacle} \\ D = \text{diam. of channel} \end{matrix}\right\}$$

and n was practically $\frac{1}{2}$. In the case of plates, both width and thickness must be taken into account. To do this three sets of experiments were made, with (*a*) plates of various widths and constant thickness, (*b*) plates of various thicknesses and constant width, and (*c*) plates for which the ratio of thickness to width was constant. In series (*a*), plotting critical velocity against reciprocal of width gave almost a straight line ; in series (*b*) so did plotting critical velocity against $(\text{width})^{\frac{1}{2}}$; while in series (*c*) the linear relationship between critical velocity and reciprocal of width was no longer an accurate representation of the results. From the photographs of the eddies, the velocity components at various sections of the stream were obtained, and the results are given in a series of graphs. The dependence of the positions of the neutral point and the centres of the eddies on the velocity of the stream was also studied. For spheres and cylinders, these distances are found to be nearly proportional to the square of the velocity, but with plates, they are proportional to the velocity itself. Some photographs of the eddies are given. W. G. B.

208. *Law of Fall of a Sphere through a Gas and the Nature of Molecular Reflection.* **R. A. Millikan.** (Phys. Rev. 22. pp. 1–23, July, 1923.)—From oil-drop experiments and theoretical considerations, an empirical law of fall is evolved to represent the resistance to motion of a sphere through a gas at any pressure. The general form is :

$$F = 6\pi\eta av[1 + (A + B\epsilon^{-ca/l})\, l/a]^{-1}$$

where a is the radius of the drop, l the mean free path, η the viscosity, and v the velocity. For oil drops in air $A = 0 \cdot 864$, $B = 0 \cdot 290$, $C = 1 \cdot 25$. Other results show that A depends both on the gas and on the material of the sphere while A B is nearly constant. The theoretical value of $A + B$ for various types of molecular reflection is compared with that deduced by experiment and the evidence is shown to point to diffuse reflection with a small fraction of specular reflection. Apparent discrepancies in the results of Gaede and Knudsen are shown to be easily explainable, and these authors' observations come well into line with the author's results. A. Wh.

209. *Physical Properties of Elements at High Temperatures.* **M. N. Saha.** (Phil. Mag. 46. pp. 534–543, Sept., 1923.)—A theoretical paper, unsuitable for abstraction, dealing with certain points which are stated to have been lightly passed over by recent workers [see Abstracts 1398 (1921) and 714 (1923)]. Referring to the work of Darwin and Fowler, the author states " no theory of dissociation-equilibrium can be said to be complete unless it takes account of the mutual interaction between matter (atoms) and radiant energy, because at high temperatures exchange of energy takes place mainly by radiation and only to a slight extent by collision." This point is then developed by a consideration of the simplest case, the binding of an electron with a proton to form an H-atom. He then proceeds to a consideration of the deduction of the law of reaction isochore for the ionisation of the H-atom. The subsequent part of the paper deals with (*a*) Fowler's work on the reaction-isobar of the ionisation of the H-atom, (*b*) electrical and optical properties of ionised gases, and (*c*) the mean free path of an electron in a mass of ionised gas. E. G.

210. *The Fine Structure of some Sodium Salts of the Fatty Acids in Soap Curds.* **S. H. Piper** and **E. N. Grindley.** (Phys. Soc., Proc. 35. pp. 269–272, Aug., 1923.)—X-ray photographs of soap curds composed of sodium laurate, sodium myristate or sodium palmitate show lines due to reflections from planes with spacings respectively equal to 33·5 Å.U., 38·5 Å.U., and 43·5 Å.U. These spacings increase uniformly with the number of CH_2 groups in the molecule, and indicate an effective length of 1·25 Å.U. for the CH_2 group. The explanation of the wide spacings and certain other close spacings observed is afforded by assuming the curds to be in the smectic state described by Friedel [Abstract 1397 (1923)]. J. S. G. T.

211. *Lattice Determinations by Means of Layer Lines.* **H. Mark, K. Weissenberg,** and **H. W. Gonell.** (Zeits. Elektrochem. 29. pp. 364–365, Aug. 1, 1923. Paper read before the Deut. Bunsen-Gesell., Hanover, May, 1923.)—Polányi's relation between the layer lines, obtained in the X-ray diagrams of rotating crystals, makes it possible to obtain directly the identity periods, and thus the distances between identical points in the lattice. The authors have used the method with a number of different crystals, including rhombic sulphur, which they have rotated about its three principal axes. Their values for *a*, *b*, and *c* agree with those of Bragg. The crystal has been proved not to be base centred as Bragg supposed. This is important, since the elementary body contains 16 atoms, while it is geometrically impossible to build up a rhombic simple, primitive, elementary body out of 16 components of equal value; thus the S atoms in the lattice cannot all act identically, and must be combined in molecules of 2, 4, or 8 atoms. H. N. A.

212. *Crystal Structure and Chemical Constitution of Basic Beryllium Acetate and Propionate.* **W. Bragg** and **G. T. Morgan.** (Roy. Soc., Proc. 104. pp. 437–451, Nov. 1, 1923.)—The coordination number of an element represents the maximum number of associating units which can be grouped round the atomic sphere; in the case of elements of medium atomic volume this number is generally six; but with small atomic volume it is diminished to four or even less. Reference is made to Wyckoff's work on the hexamminonickel halides, that of Wyckoff and Posnjak on ammonium platinichloride, and of Wyckoff on cæsium dichloriodide. W. L. Bragg's work on $NaNO_3$ and $CaCO_3$ is also mentioned. The elements of the first short period, from lithium to fluorine, have small atomic volumes and low atomic numbers, and as a rule their coordination numbers do not exceed four, and are sometimes less; in the borotungstates boron appears to have a coordination number 6, though in other compounds the number is 4. For many beryllium compounds the number is 4; basic beryllium acetate has been fully investigated; the crystals form regular octahedrons, and are singly refracting. The structure suggested is symmetrical about a central oxygen atom, the four Be atoms standing at the corners of a regular tetrahedron surrounding this; the six acetate groups are arranged symmetrically between the pairs of Be atoms; in a diagram they are shown outside the tetrahedron, but in the text they are described as lying on the edges of the tetrahedron. It is supposed that the electrons are redistributed, two electrons from the beryllium atoms going to the central O, completing its external octet so that it resembles neon in its outer form, though its charge is $(-\,2e)$. Six other elctrons from the Be atoms go to the six acetate groups, so that the Be atoms now resemble helium, but with charges $(+\,2e)$. The X-ray evidence shows that these molecules are arranged in the same manner as that of the carbon atoms in the diamond; the propionate, on the other hand, gives crystals which probably belong to the monoclinic prismatic class. H. N. A.

213. *Spectroscopic Magneton Numbers.* **A. Sommerfeld.** (Phys. Zeits. 24. pp. 360–364, Sept. 1, 1923.)—From the considerations here brought forward by the author and from those of Pauli, Epstein, and Gerlach [Abstracts 1975 and 2279 (1923)] it seems that the riddle of the magneton is now solved. The Weiss unit of the magnetic moment is shown as apparent, the quantum theory unit as real. The whole numbers which Epstein and Gerlach calculate according to Pauli's rule find a support in the meantime systematised Cr and Mn spectra. The sequences of the magneton numbers 3, 4, . . . 6 in the case of Cr and 4, 5, . . . 5(7) in the case of Mn are in favour of the step-by-step upbuilding of the elements in the periodic system, so that the magnetic moment always advances by a full unit, the mechanical moment as regards the inner quantum number answering to it always by a half unit. The thus expressed doubled magnetic effect of the mechanical moment j_s appears to be the real ground of the magneto-optic as well as of the magneto-mechanical anomalies. The whole magneton numbers of the ions calculated by Epstein and Gerlach show that the spatial quantelation maintains itself in spite of the disturbances and collisions which they must meet with in solutions. The quantic adjustments must then proceed more quickly than the disturbances follow each other. Hence Pauli's thesis can be understood according to which full quantic orientation prevails in the gases O_2 and NO at relatively high gas pressures. In the case of the even terms the values of j given earlier by the author are to be reduced by a half unit and the figure serving for their geometrical construction is to be modified. For the odd-number terms, on the contrary, the earlier given j values remain and their construction is unchanged. J. J. S.

214. *A Bohr-Langmuir Transformation.* **G. C. Evans.** (Nat. Acad. Sci., Proc. 9. pp. 230–236, July, 1923.)—The author considers the Bohr atom and the Langmuir atom with a quantised force, in regard to the question as to whether the "events" of one system are equivalent to the "events" of the other, and shows that although one system cannot be the transform of the other by any continuous contact transformation, both are, however, equivalent by a valid transformation which is a contact transformation locally, but not in *extenso*. In particular, Langmuir's completely static atom is equivalent to the Bohr atom with circular orbit. The question of reality and preference is discussed in terms of transference processes, which carry one system into the other. The paper is mathematical throughout. H. H. Ho.

215. *The Electrical Structure of Matter.* **E. Rutherford.** (Nature, 112. pp. 409–419, Sept. 15, 1923. Inaugural Address to the Brit. Assoc., Liverpool).—Attention is directed to the main features of the advance in knowledge of the nature of electricity and matter during the last quarter of a century. After outlining the discoveries made relative to the electron, facts are brought forward which lead to the natural supposition that the hydrogen nucleus is the atom of positive electricity or positive electron, analogous to the electron but differing from it in mass. Electrical theory shows that the mass of a given charge of electricity increases with the concentration and the greater mass of the hydrogen nucleus would be accounted for if its size were much smaller than that of the electron. Such a conclusion is supported by evidence obtained from the study of the close collisions of α-particles with hydrogen nuclei. It is found that the hydrogen nucleus must be of minute size, of radius less than the electron (*i.e.* less than 10^{-13} cm.); also the experimental evidence is not inconsistent with the view that the hydrogen nucleus may actually be much smaller than the electron.

There is the strongest evidence that the atoms of matter are built up of two electrical units, namely, the electron and the hydrogen nucleus or proton. It is probable that these two are the fundamental units which build up matter. The mass of the atom is the sum of the electrical masses of the individual charged units composing its structure, and there is no need to assume that any other kind of mass exists. It is, however, pointed out that the actual mass of an atom may be somewhat less than the sum of the masses of component positive and negative electrons when in the free state. On account of the very close proximity of the charged units in the nucleus of an atom, and the consequent disturbance of the electric and magnetic fields surrounding them, such a decrease of mass is to be anticipated on general theoretical grounds.

The study of the scattering of α-particles, the scattering of X-rays by light elements, and the diffraction of X-rays by crystals, leading finally to the conclusion that the atomic number of an element is a measure of its nuclear charge, is considered. The application of the quantum theory by Bohr to explain the structure of the atom is briefly outlined. Not only does the theory of Bohr (which defines the outer structure of the atom) offer a general explanation of the optical and X-ray spectra of the atom, but it accounts in detail for many of the most characteristic features of the periodic law of Mendeleéff. The problem of the structure of the nucleus is inherently more difficult than the allied problem of the structure of the outer atom. The author's experiments on release of swift hydrogen nuclei from the elements B, N, F, Na, Al, and P, when bombarded by swift α-particles, leave little doubt that these H nuclei form an essential part of nuclear structure. Speed of ejection of these nuclei depends upon the velocity of the α-particle and on the element bombarded. The speed of H-nuclei liberated in the backward direction is always less than in the forward direction. This is explained on the assumption that hydrogen nuclei are not built into the main nucleus but exist as satellites, probably in motion round a central core. The liberation of H-nuclei only occurs in elements of odd atomic number namely, 5, 7, 9, 11, 13, and 15, the elements of even number being unaffected. It is indicated how the study of isotopes gives experimental support to the view that the nuclei of all atoms are ultimately built up of protons of mass nearly one and of electrons.

The latter part of the address is devoted to the consideration of the question of the energy relations involved in the formation and disintegration of atomic nuclei, first opened by the study of radio-activity.

E. A. O.

216. *Effective Cross-Section of Gas Molecules towards Slow Electrons.* II. **C. Ramsauer.** (Ann. d. Physik, 72. 5. pp. 345–352, Sept. 28, 1923.)—A continuation of previous work [Abstract 1494 (1922)]. The present paper gives the results obtained for krypton and xenon, which are very similar to those previously obtained for argon. For these three gases the effective cross-section increases to a maximum which is about 4 or 5 times that given by the kinetic theory of gases, this maximum corresponding to electron velocities of 13·2 volts for argon, 11·3 volts for krypton, and 6·4 volts for xenon. For the smallest velocities investigated (about 0·75 volt) the effective cross-section is less than 1/7 of that given by the kinetic theory of gases.

A. W.

217. *Internal Pressure and Molecular Sphere of Action.* **W. Herz.** (Zeits. Elektrochem. 29. pp. 338–339, July 1, 1923.)—According to Stefan the molecular diameter is given by the equation $\rho = \gamma/B$, where γ is the surface tension, and B is the internal pressure; while van der Waals gives $2\gamma/B$ as the value of the radius of the molecular sphere of action, which is thus twice the molecular diameter. The internal pressure can be obtained, either from Stefan's equation $B = L/2v$, where L is the heat of vaporisation and v is the specific volume, or from the correction term of the van der Waals equation, which gives $B = a/v^2$. The author gives a table, with these two values, for fifteen organic compounds; they are of the same order, but in some cases there are considerable differences; with compounds containing chlorine the Stefan values are throughout smaller than those derived from the van der Waals equation. In homologous series of organic compounds the results show that the radius of the molecular sphere of action generally increases with increasing molecular weight; isomers have unequal spheres of action. H. N. A.

218. *The Effect of Temperature on Gravitative Attraction.* **P. E. Shaw** and **N. Davy.** (Phys. Rev. 21. pp. 680–691, June, 1923.)—A paper similar to that referred to in Abstract 610 (1923). W. R. C.

219. *Statistical Theory of Spontaneous Fluctuations in Energy, Pressure, and Density.* **K. C. Kar.** (Phys. Rev. 21. pp. 672–679, June, 1923.)—The fluctuation of a quantity, such as the energy, is defined as the ratio of the average deviation from the mean energy to the mean energy. The following expressions are deduced from a new statistical theory for ordinary temperature and pressure: Fluctuation in energy at constant volume $= \sqrt{(2/\gamma n f)}$ and at constant temperature $= 2/f\sqrt{n}$; Fluctuation in pressure or density at constant temperature $= 1/\sqrt{n}$; where n is the number of molecules, f the number of degrees of freedom of each, and γ the ratio of total energy to kinetic energy. At the critical condition the first of these becomes $(12/\gamma n f)^{1/4}$ and the last $(6/n)^{1/4}$. The expressions obtained by Smoluchowski, Hauer, Fürth, and Laue are shown to be special cases of the above. Relations are obtained between the various types of fluctuations for the case of an ideal gas. AUTHOR.

220. *The Connection between Schwarzschild, Einstein, and Trefftz's Solutions of the Equations of Gravitation.* **M. v. Laue.** (Preuss. Akad. Wiss. Berlin, Ber. 5. pp. 27–31, 1923.)—The author first recalls that a solution of Einstein's generalised equations:

$$R_{ik} - \tfrac{1}{2}Rg_{ik} - \lambda g_{ik} = -kT_{ik}$$

valid in regions distant from gravitating matter, is obtained by finding the form of ds^2 for the interior of a sphere ($r \leq r_m$) of matter of density μ and then setting $\mu = 2\lambda/c^2k$. This gives the solution:

$$ds^2 = dr^2/(1 - \lambda r^2) + r^2(d\theta^2 + \sin^2\theta d\phi^2) - c^2dt^2 \quad \ldots\ldots \quad (1)$$

and the sphere $r \leq r_m$ may be extended to cover the whole "world." This method of obtaining the solution leads to the supposition that space is filled with a very rarefied "nebular matter." On the other hand, near a gravitating particle:

$$ds^2 = dr^2/(1 - \gamma) + r^2(d\theta^2 + \sin^2\theta d\phi^2) - c^2(1 - \gamma)dt \quad \ldots\ldots \quad (2)$$

where $\gamma = \frac{1}{3}\lambda r^2 + \alpha/r$.

The present paper shows that the transition is accounted for if we suppose that in a sphere of radius $(3\alpha/2\lambda)^{1/3}$ surrounding the particle the nebular matter is absent. The mass of the missing matter is then precisely equal to that of the particle, and it may therefore be thought of as concentrated there. The space outside the empty sphere is not affected by the concentration, so that (1) is valid there; in the hollow (2) holds, the two solutions passing into one another continuously at the boundary.

M. H. A. N.

221. *The Mechanism behind Relativity.* **W. Peddie.** (Roy. Soc. Edinburgh, Proc. 43. 2. pp. 149–153, 1922–1923.)—The author points out that the supposition that every electron is embedded in an ether of its own, at rest relative to itself, is not incompatible with the restricted principle of relativity, provided that electromagnetic waves are supposed to be propagated simultaneously in each of these ethers with velocity C.

M. H. A. N.

222. (1) *On the General Theory of Relativity.* (2) *Note on the foregoing.* (3) *Theory of the Affine Field.* **A. Einstein.** (Preuss. Akad. Wiss. Berlin, Ber. 5. pp. 32–38; 12. pp. 76–77, and 17. pp. 137–140, 1923.)—In Eddington's generalisation of Weyl's relativity theory the primitive quantities in terms of which the space-time manifold is described are not the fourteen tensors g_{ik}, ϕ_μ, but the forty components, $\Gamma^\alpha_{\mu\nu}$, of the affine field. The contracted Riemann tensor of the second rank, built up from these functions in the usual way, is split into its symmetrical and anti-symmetrical parts, and these are equated respectively to the metrical tensor, g_{ik}, and the electrical tensor, F_{ik}. These equations, however, are merely definitions in the Eddington theory and can only give information when combined with further equations, determining the Γ's as functions of g's and F's. It is the object of the present three papers to obtain the required forty equations from an action principle, $\delta\int\mathbf{H}dt = 0$ . . . (1), where $\mathbf{H}$ is a scalar density, and the variation is with respect to the $\Gamma^\alpha_{\mu\nu}$ as independent variables. [*Note.*—The symbolism is different in all three papers. We follow that of the third paper.]

Writing
$$\gamma_{kl} = -\partial\Gamma^\alpha_{kl}/\partial x_\alpha + \tfrac{1}{2}(\partial\Gamma^\alpha_{k\alpha}/\partial x_l + \partial\Gamma^\alpha_{l\alpha}/\partial x_k) + \Gamma^\alpha_{k\beta}\Gamma^\beta_{l\alpha} - \Gamma^\alpha_{kl}\Gamma^\beta_{\alpha\beta}$$
$$\phi_{kl} = \tfrac{1}{2}(\partial\Gamma^\alpha_{k\alpha}/\partial x_l - \partial\Gamma^\alpha_{l\alpha}/\partial x_k),$$

it is first shown that, provided $\mathbf{H}$ is a function of γ_{kl} and ϕ_{kl} only, equation (1) leads to the integrals $\mathbf{g}^{kl}{}_{;\alpha} + \tfrac{1}{3}\delta^k_\alpha\mathbf{i}^l + \tfrac{1}{3}\delta^l_\alpha\mathbf{i}^k = 0$ . . . (2), forty in number. Here $\mathbf{g}^{kl} = \partial\mathbf{H}/\partial\gamma_{kl}$, $\mathbf{i}^l = \partial\mathbf{f}^{l\sigma}/\partial x_\sigma$, $\mathbf{f}^{l\sigma} = \partial\mathbf{H}/\partial\phi_{l\sigma}$, and $;_\alpha$ denotes covariant derivation for x_α. The *fundamental tensor* is defined from $\mathbf{g}^{kl}$ by the equations $\mathbf{g}^{kl} = g^{kl}\sqrt{-|g_{kl}|}$, $g_{k\alpha}g^{l\alpha} = \delta^l_k$, and the "reduction of indices" is understood to be effected with the help of this tensor. Since $\mathbf{i}^l$ is the divergence of $\mathbf{f}^{l\sigma}$, it is to be identified with the electric current vector. Equations (2) can then be solved in the form:

$$\Gamma^\alpha_{kl} = \tfrac{1}{2}g^{\alpha\beta}\left(\frac{\partial g_{k\beta}}{\partial x_l} + \frac{\partial g_{l\beta}}{\partial x_k} - \frac{\partial g_{kl}}{\partial x_\beta}\right) - \tfrac{1}{2}g_{kl}i^\alpha + \tfrac{1}{6}\delta^\alpha_k i_l + \tfrac{1}{6}\delta^\alpha_l i_k.$$

A definite form has now to be chosen for $\mathbf{H}$. In the first paper $\mathbf{H} = 2\sqrt{-r}$, $(r = |r_{ik}|)$, is adopted, where $r_{ik} = \gamma_{ik} + \phi_{ik}$ . . . (3), *i.e.* r_{ik} is the contracted Riemann tensor formed from the Γ's. In this case, if r^{ik} is the "prepared" minor of r_{ik} in r and $\mathbf{r}^{ik} = r^{ik}\sqrt{-r}$, it is shown that $\mathbf{g}^{kl}$ and $\mathbf{f}^{kl}$ are respectively the symmetrical and anti-symmetrical parts of $\mathbf{r}^{kl}$. In the case of no electric field ($\mathbf{f}^{kl} = 0$), $\gamma_{ik} = g_{ik}$, giving the original Einstein equations. In general the equations of the field are $r_{kl} = R_{kl} + \tfrac{1}{6}[\partial i_k/\partial x_l - \partial i_l/\partial x_k] + \tfrac{1}{6}i_k i_l$ . . . (3), where R_{kl} is the Riemann tensor formed *from the g's*. The antisymmetrical part gives (in " laboratory " units) $\phi_{kl}/\lambda^2 = \frac{1}{6}(\partial i_k/\partial x_l - \partial i_l/\partial x_k)$, so that an extremely weak electric current must be supposed to exist at all parts of a non-zero field.

In his first paper the author concluded from the fact that some of the equations are altered by changing the sign of the electric quantities, that solutions of a different character will correspond to positive and negative electricity, but in the " note " a second action function is produced, which, on variation with respect to $\mathbf{g}^{kl}$ and $\mathfrak{f}^{kl}$ gives equations (3) above ; and this action is an even function of the electric quantities. The above suggestion is therefore withdrawn.

In the third paper the supposition that **H** is a function of $\gamma_{ik} + g_{ik}$ is abandoned. Whatever the form of **H**, not only $\mathbf{g}^{\mu\nu}d\gamma_{\mu\nu} + \mathfrak{f}^{\mu\nu}d\phi_{\mu\nu}$, but also $\gamma_{\mu\nu}d\mathbf{g}^{\mu\nu} + \phi_{\mu\nu}d\mathfrak{f}^{\mu\nu}$ is a perfect differential. The field equations are therefore derivable by varying an integral $\int \mathbf{H}^* dt$ with respect to $\mathbf{g}^{\mu\nu}$ and $\mathfrak{f}^{\mu\nu}$. The function $2\alpha\sqrt{-g} - \frac{1}{2}\beta f_{\mu\nu}\mathfrak{f}^{\mu\nu}$ is chosen and the integrals

$$R_{\mu\nu} - \alpha' g_{\mu\nu} = -k[(-f_{\mu\sigma}f^{\sigma}_{\nu} + \tfrac{1}{4}g_{\mu\nu}f_{\sigma\tau}f^{\sigma\tau} + \beta' f_\mu f_\nu]$$

and
$$-f_{\mu\nu} = \frac{1}{\beta'}(\partial i_\mu/\partial x_\nu - \partial i_\nu/x_\mu)$$

obtained. These are practically identical with the equations derived by Weyl from his action principle. The second equation shows β' must be small and the first therefore gives approximately the " classical " equations.

The question of experimental discrimination is not discussed.

M. H. A. N.

223. *Propagation of Light in the Relativity Theory.* **W. Gordon.** (Ann. d. Physik, 72. 6. pp. 421–456, Sept. 28, 1923.)— In the first part of the paper it is shown that the effect of matter on electromagnetic processes is equivalent to that of a certain gravitational field. More precisely, if the natural g_{ik} are replaced by $\gamma_{ik} = g_{ik} + (1 - 1/\epsilon\mu)u_i u_k$ and the lowering and raising of indices effected by this new fundamental tensor, all the electromagnetic equations remain unaltered in form save the " dielectric " equation which takes the simple form $\sqrt{\epsilon}F_{ik} = \sqrt{\mu}H_{ik}$ analogous to the equation for empty space (u_i is the velocity of the matter). In the case of non-conducting uncharged homogeneous media the equations become identical with those in a vacuum when a gravitational field γ_{ik} is present. If the g_{ik} have Galilean values this leads immediately to the well-known formula $dx/dt = c/\sqrt{\epsilon\mu} + (1 - 1/\epsilon\mu)v$. A geometrical construction is deduced, in the general case, for an element of the path of a light ray in matter. If PR is an element of a light track in the original field, g_{ik}, (*i.e.* in vacuo), and PS its projection on the direction of motion of the matter at P, an element of a light track in the moving matter is given by the vector sum PR $-$ $(\sqrt{\epsilon\mu} - 1)$PS, the second term representing what was in pre-relativity mechanics called the " drag of the ether." An action function is given.

In the second part of the paper extensive generalisations of the definitions and properties of the symbols *div* and *curl* are given, applicable to tensors of any rank, and these are employed in Part 3 to show how the Hertzian vectors may be used with advantage in the specification of

the field. In Part 4 inequalities are found which must be satisfied in order that the expression "light ray" should be significant, and it is shown that if these are satisfied the light tracks in matter are actually given by the null tracks in the fictitious gravitational field : $\gamma_{ik} dx_i dx_k = 0$.
M. H. A. N.

224. *Space.* **N. Campbell.** (Phil. Mag. 46. pp. 1002–1012, Nov., 1923.)—The present paper discusses the question of the connection between the conception of space and the experimental geometry dealt with on a previous occasion (Phil. Mag. 44. p. 15, 1922). It is concluded that space, though based on the experimental concept "position," which is a typical pure derived magnitude, is itself a hypothetical idea and involved in theories rather than in laws. A brief and very summary outline of the theory of space, as it appears in classical physics, is given, and a few remarks offered on the alterations of this theory, rendered necessary by the general theory of relativity. H. H. Ho.

METEOROLOGY AND GEO-PHYSICS.

225. *Atmospheric Turbidity.* **A. Defant.** (Akad. Wiss. Wien, Ber. 130. 2a. No. 7–8. pp. 383–403, 1921.)—The case is considered for extra-tropical latitudes. It is shown that the irregular movement can be best characterised by determining the three components of the turbulence. Instead of these, however, the distribution of normal and tangential stress in the horizontal plane can be obtained by constructing the ellipse of principal stresses. This is done for three special cases. It is also found that on rising above the surface there is a rapid increase in the value of the stresses, and also at a height near 4000 m. a change in their direction of about 90° occurs. There seems to be a simple annual period of change—a maximum in late winter and a minimum in summer. The stress components can be calculated both from wind and pressure observations.
W. A. R.

226. *Crustal Movements and Temperature.* **H. H. Poole.** (Phil. Mag. 46. pp. 406–417, Sept., 1923.)—An examination of the factors affecting the temperature gradient at the surface of the earth is made, and it is found that they all tend to reduce the gradient. Such factors are variable conductivity; the effect of circulating waters; evolution of heat in volcanic extrusions; and climatic changes. Owing to these effects the smallness of the temperature gradient as observed cannot be accepted as evidence against the uniform distribution of radio-activity throughout the continental layer. The continents may become stranded at the end of Joly's "revolutionary" periods on banks of solidified magma, and the heat subsequently evolved from their lower levels used in melting these banks [see Abstract 48 (1924)]. W. A. R.

227. *The Physical Conception of the Gradient Curves of Rivers.* **F. M. Exner.** (Akad. Wiss. Wien, Ber. 131. 2a. No. 2. pp. 147–153, 1922.)——The process whereby rivers cut out their beds in the course of time in a very definite manner according to the depth, appears to admit of theoretical treatment from a physical standpoint. An initial watercourse starting with any variable inclination is found gradually to assume a form termed technically the normal gradient curve and characterised by a gradual decrease of fall in the flow direction of the water. Penck is of the opinion that these gradient lines are not definite geometrical curves, whereas Sternberg's earlier assumption of a logarithmic curve is supported by Forchheimer's conclusions with respect to the courses of several rivers, including the Middle Rhine and Maas. The present paper attempts a mathematical investigation of the problem and concludes in favour of Forchheimer and Sternberg. H. H. Ho.

228. *Gravity Gradients in Toné Basin.* **I. Yamamoto.** (Imp. Japanese Geodetic Com. Tôkyô, Report No. 3. [90 pp.], 1923. In English.)—This is a full account of a gravity survey in the Toné basin, carried out by means of a pair of Eötvös balances. The final results show many kinds of field peculiarities, but these are exclusively in the horizontal gradients. The general centre of the horizontal gravity is Mount Tsukuba, whose influence is traceable in almost all parts of the Kwantô Plain, as far as some eighty kilometres. The influence of the great River Toné is found to be small except for a narrow limit of partial area near the mouth.
E. H. B.

229. *Isostasy.* **W. Bowie.** (Washington Acad. Sci., J. 13. pp. 267–269, July 19, 1923.)—Some account of the establishment of recent gravity stations is given. One of the principal problems of the moment is the interpretation of large gravity anomalies in stations close together. The results indicate that the anomalies are due not to the lack of adjustment, but to the existence of large irregularities in the rocks near the surface.
W. A. R.

ASTRO-PHYSICS.

230. *The Distribution of Brightness on the Sun's Disc and the Temperature Gradient in the Sun's Atmosphere.* **R. Dietzius.** (Akad. Wiss. Wien, Ber. 131. 2a. No. 1. pp. 15–35, 1922.)—Schwarzschild and Defant's work, developing Schuster's mathematical investigation of the decrease in brightness from the sun's centre to limb, seemed consistent with the supposition that the sun consists of a nucleus which radiates like a black body, surrounded by a cooler gaseous atmosphere which scatters this radiation. But St. John's work, developing Evershed's discovery of radial motion in sunspots, assumes that the sun is gaseous throughout, and that the Fraunhofer lines are produced by absorption at different levels in the gas. The present paper is written to show by mathematical proof that Schuster's law of decreasing brightness can be explained quite as well, or even better, on this theory of a completely gaseous sun.
M. A. E.

231. *Light-Curve and Orbit of CG Cygni.* **Ch'ing-Sung Yü.** (Astrophys. J. 58. pp. 75–85, Sept., 1923.)—The light-curve of this variable star is determined from a series of 272 extra-focal observations made with the Thaw Photographic Refractor of the Allegheny Observatory during 1922. AUTHOR.

232. *Colour Index and Photographic Light Curve of Nova Aquilæ, 1918·4 (No. 3).* **H. Shapley.** (Harvard Coll. Obs., Annals, 81. No. 7. pp. 239–243, Dec., 1923.)

233. *Declinations of 336 Stars.* **S. G. Barton.** (Astron. J. 35. pp. 109–113, Oct. 2, 1923.)

LIGHT.

234. *Magnitude Errors with the Thermoelectric Photometer.* **H. T. Stetson** and **E. F. Carpenter.** (Astrophys. J. 58. pp. 36–45, July, 1923.)—Some improvements have been made in the thermoelectric photometer previously described [Abstracts 1010, 1011 (1916)]. These include the substitution of a 20-watt, 6-volt lamp for the 200-watt, 50-volt one previously used. A more sensitive galvanometer is also used. The time necessary for making a determination is much reduced and the gain in sensitivity is from 100–200 %. The probable instrumental error in magnitude is 0·007. A greater source of error lies in non-uniformity of the photographic plates. This was tested in two ways. Firstly a series of exposures of an artificial star image was taken on various portions of a plate, and secondly a series of areas on a plate were exposed to uniform diffused radiation. These correspond to focal and extra-focal magnitude determinations respectively. When allowance is made for systematic errors, and precautions are taken to secure the best performance of the plates, the probable magnitude error appears to be 0·02 for focal and 0·03 for extra-focal determinations. A. Wh.

235. *Effect of Barometric Pressure on the Candle-Power of the Hefner Lamp.* **A. Boltzmann** and **A. Basch.** (Akad. Wiss. Wien, Ber. 131. 2a. No. 1. pp. 57–80, 1922.)—Describes a series of experiments made with the object of determining the pressure correction for the Hefner standard. The pressure variation was obtained by carrying out photometric measurements at 4 stations situated at different heights above sea-level (up to 3100 metres). The pressure coefficient found was 0·0004 per mm. of mercury. This figure is in agreement with that of Butterfield, Haldane, and Trotter and is nearly four times as great as that found by Liebenthal [see Abstract 2402 (1923)]. J. W. T. W.

236. *Some Refractive Indices of Benzene and Cyclohexane.* **J. W. Gifford** and **T. M. Lowry.** (Roy. Soc., Proc. 104. pp. 430–437, Oct. 1, 1923.)—Although chemists have measured vast numbers of refractive indices for the D-line of sodium, and even recorded the refractive indices for the C, F, and G lines of hydrogen, these data have only represented casually selected points on curves of unknown form. It was a matter of urgency in refractive dispersions to analyse the forms of the dispersion curves, classify them, and see if independent constants of refractive power and dispersive power could be calculated from experimental data. Direct measurements with a hollow prism, using a fluorescent eyepiece, give a greater accuracy of reading than in instruments of the total-reflection type. Both benzene (C_6H_6) and cyclohexane (C_6H_{12}) are liquid at ordinary temperatures, freeze above the melting-point of ice, and can be freed from all but isomorphous impurities by cooling, crystallising, and draining the crystals in a centrifuge. The wave-lengths selected for the measurements are of some importance. It was anticipated that the refractive-dispersion of the simpler types of compounds might be expressed by a simple equation of the form $n^2 = k_1 + k_2/(\lambda^2 - \lambda_0^2)$ containing three arbitrary constants. This expectation was actually realised in the case of cyclohexane, but it was found to be quite impossible to fit the curve for benzene in a similar manner. Cyclohexane yields no absorption bands, even in the ultra-violet region of the spectrum, but the optical properties of benzene are singularly complex, its absorption spectrum showing seven absorption bands. The necessary experiments are described in some detail. For the purpose of the temperature-refraction coefficients three exceptionally bright lines were chosen.

Wave-length and element ...	He7065(B′)	Fe5270(E)	He4472
T.R. coefficient benzene	− 0·0006357	− 0·0006674	− 0·0006708
T.R. coefficient cyclohexane .	− 0·0005376	− 0·0005515	− 0·0005647

From these, coefficients for other wave-lengths were interpolated in proportion to the indices, and the refractive indices in the table given in the paper corrected accordingly. The average difference for 20 wave-lengths was 0·00006. T. C. H.

237. *Diffraction Effects in Spherical Aberration.* **J. Fischer.** (Ann. d. Physik, 72. 5. pp. 353–399, Sept. 28, 1923.)—A mathematical analysis of the subject in the special case of a bundle of rays for which the caustic may be regarded as the evolute of a parabolic cylinder. J. W. T. W.

238. *Note on a Departure from Fresnel's Laws of Reflection.* **N. K. Sur.** (Phys. Rev. 21. pp. 699–700, June, 1923.)—Reflection of light from the common surface of two media having the same refractive index for certain wave-lengths was studied, the media employed being, first, freshly split rock-salt or clean glass against a suitable mixture of carbon disulphide and benzene, and second, glycerine against turpentine. The reflected light did not vanish completely at the point in the spectrum where the refractive indices were equal, but possessed a definite intensity that was practically constant at different angles of incidence. This reflection can hardly be due to contamination of the surface, but must be due to a genuine change of refractive index in the surface layer. AUTHOR.

239. *Reflection of Light from a Sphere.* **E. M. Berry.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 679–682, Sept., 1923.)—When parallel light is reflected from a small perfectly reflecting sphere, the illumination is approximately independent of the angles of incidence and reflection. An expression is found for the illumination at different angles at a distance R from the centre of the sphere (radius r). The degree of approximation to which the illumination is independent of angle is exceedingly close for all angles up to 80° when $r/\mathrm{R} < 0{\cdot}001$. J. W. T. W.

240. *Theory of Visual Space.* **K. Horovitz.** (Akad. Wiss. Wien, Ber. 130. 2a. No. 7–8. pp. 405–420, 1921.)—The visual space of the eye at rest is conceived as a relief. This way of viewing the matter makes the observed optical perceptions comprehensible. The possible changes in the visual-space can be represented in the relief either through a change in the depth of relief or a change of the point of vision. The phenomena of micropsy and macropsy correspond to a change of the relief through virtual shifting of the point of vision, since with them the appearance of smallness is connected with moving out. For their coming about it is essential that a disturbance of the picture releases innervation impulses. Hereby impulses as strong as possible are sent out unless through accommodation the picture is made indistinct. It follows upon this that a change of the sharpness of vision is connected with a change of the perception of magnitudes, and this consequence can be proved through various investigations—change of the sharpness of vision through dazzling and through change of the intensity of illumination and of colour, passing from binocular to monocular vision.

The known researches on the influence of dazzling on the perception of size were verified and find their explanation on the basis of the above-mentioned point of view. Investigations with change of the dazzling of the field of vision appear specially suitable for the decision of the question how far the picture on the retina and how far the movements of the eye contribute to the bringing about of space perception. J. J. S.

241. *Determinations of Brightness in the Red-Blind Colour System.* **F. Exner.** (Akad. Wiss. Wien, Ber. 130. 2a. No. 7–8. pp. 355–361, 1921.)—A comparison was made between the vision of a red-blind person and that of one with normal trichromatic sight—the author himself. First, as to the comparative brightness in the two cases of coloured pigments, three pigments were chosen which agreed very closely with the three fundamental sensations in Helmholtz's system which are denoted by R, G, and B. The results of tests of the apparent brightness are given as follows: $R = 0{\cdot}290$, $G = 0{\cdot}455$, $B = 0{\cdot}135$ for the dichromatic eye, and $R = 0{\cdot}420$, $G = 0{\cdot}450$, $B = 0{\cdot}120$ for the trichromatic eye. The colour of R was described by the red-blind observer as grey or as grey with a bluish tinge. Further tests were carried out, including observations on the solar spectrum. From the various tests made it appears to follow that the law of the additivity of variously coloured light holds for the red-blind person just as for the trichromatic and that his intensity curve in the spectrum is obtained similarly through summation of the separate excitations of his fundamental sensations. Of the latter he has only two, yellow and blue, and it cannot be doubted that this first comes about through the coincidence of the normal R and G curves; with him the R curve is covered with the normal G curve. It is surprising that in spite of that the ratio of the brightness of the saturated fundamental sensations yellow : blue is actually smaller than the ratio green : blue for the trichromatics, which is just the opposite of what would be expected. Whether that is only caused by the defective sensitiveness of the author's eye for blue or is evidence of a general phenomenon can only be decided by further investigations. J. J. S.

242. *The Colour of the Sea.* **W. Shoulejkin.** (Phys. Rev. 22. pp. 85–100, July, 1923.)—This work is an attempt at a quantitative investigation, as far as possible, of all the fundamental phenomena connected with the transmission of light through sea water. Such an investigation involves the obtaining of the spectrum of the diffused light emitted by the sea, for a series of typical cases. The colour of seas and lakes is found to be explained neither by (1) the intrinsic colour of water due to selective absorption $f(\lambda)$, nor (2) the Rayleigh scattering by microscopic particles or bubbles of gas $\frac{1}{2}a/\lambda^4$, alone. A combination of these two causes, however, together with (3) selective reflection $\phi(\lambda)$ by larger particles (clay, plankton, etc.) and (4) light reflected from the sky, seems to be adequate, if the effect of waves is taken into account. The general theory is next developed, and then, using experimentally determined values of the selective reflection $\phi(\lambda)$ for a brown clay suspension, curves are computed for various values of the proportion of such particles β, and for the scattering coefficient α, which give resultant colours varying from green to brown, as determined by optical synthesis. By use of a colloidal solution of rosin in alcohol coloured with Redulin blue, a model of the sea was made which gave spectrophotometric curves agreeing closely with the theory. The theory of the Secchi disc is also given and the relation derived between the coefficient of diffusion α and the maximum depth at which the disc is visible. Coefficients computed from disc observation for various lakes agree with those obtained from the spectral distribution curves of Aufsess. H. H. Ho.

243. *Colour-Mixture.* **M. Luckiesh.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 657–660, Aug., 1923.)—Description of a simple means of demonstrating the effects of the mixture of the three primary colours on a large or small scale. J. J. S.

244. *Ultra-Violet Dosage with Quartz Mercury-Vapour Lamp.* **J. M. Eder.** (Akad. Wiss. Wien, Ber. 131. 2a. No. 1. pp. 37–38, 1922.)—The Eder-Hecht neutral wedge may be used for ultra-violet photometry up to 313 $m\mu$. The wedge constant differs slightly for different sources, and this must be allowed for when the wedge is used for dosage or photochemical measurements. J. W. T. W.

245. *Visibility of Red Light.* **R. A. Houstoun** and **W. M. Heddle.** (Phil. Mag. 46. pp. 699–706, Oct., 1923.)—Some observers see the red end of the spectrum much dimmer than others. The object of this investigation is to see whether these are an extreme case of normal variation or not, and to find to what extent they occur. Using a grease-spot photometer and a pure red light, the vision of 604 students forming essentially a random distribution is examined. A table of results is given, showing a large variation in red-blindness, represented by numbers ranging from 0·4 to 2·2. These extremes refer to one person each; the numbers 0·9 and 1·0 refer to 131 and 120 persons respectively. The distribution is asymmetrical, and, so far as can be estimated, is continuous. In the results of this survey normal variation covers everything. From the figures and other previous experiments there is no doubt that certain individuals can be very insensitive to red and yet have excellent colour vision, while colour-blind individuals can have normal sensibility in the red, though this is unusual. The original Young-Helmholtz theory does not cover this distribution. A table in amplification of the results of a previous research is also given. G. A. S.

246. *Dispersion and Scattering of Light by Complex Anisotropic Molecules.* **L. V. King.** (Roy. Soc., Proc. 104. pp. 333–357, Oct. 1, 1923.)—Observations by Cabannes and others have shown that the light scattered by various gases in a direction at right angles to the incident beam is not completely polarised. This is accounted for by Cabannes on the theory of the simple anisotropic molecule as developed by Langevin to account for electric and magnetic double refraction. Such a molecule contains a single dispersion electron acted on by unequal quasi-elastic restoring forces along three principal directions and capable of vibrating with three different frequencies. The present paper extends the theory to gaseous and liquid media composed of complex anisotropic molecules in which there are a number of dispersion charges not necessarily equal, whose principal directions of vibration are not parallel. For an isotropic medium in which all molecular orientations are equally probable, a general dispersion formula of the Lorentz type is derived. In gaseous media, owing to continual changes of position, each molecule contributes independently to the intensity of the scattered radiation. For unpolarised incident light of intensity I, the depolarisation ρ is the ratio of the minimum to the maximum intensity when the light scattered at right angles is examined by a Nicol prism, and, as observed in gases, is a quantity characteristic of the molecule. The intensity $I_s(\theta)$ of light of wavelength λ scattered in a direction θ with the incident beam to a distance r from a volume V is given by the formula:

$$\frac{r^2 I_s(\theta)}{VI} = \frac{1}{2}\frac{\pi^2}{\lambda^4}\frac{(\mu^2-1)^2}{n}\cdot\frac{6(1+\rho)}{6-7\rho}\left[1+\frac{1-\rho}{1+\rho}\cos^2\theta\right] \dots \quad (1)$$

where μ is the refractive index of the medium corresponding to molecular density n. The corresponding expression for the coefficient of extinction by scattering is:

$$k = \frac{8\pi^3}{3\lambda^4}\frac{(\mu^2-1)^2}{n}\cdot\frac{6+3\rho}{6-7\rho} \dots\dots\dots \quad (2)$$

A remarkable feature of these formulæ is their invariance with respect to such details of molecular structure as number and magnitude of dispersion charges, their position, and the mutual orientation of their principal directions.

Formulæ of the same invariant character are derived for scattering, depolarisation, and extinction of light in gaseous mixtures. In particular the depolarisation of air calculated in terms of that of its principal constituents, oxygen and nitrogen, is in good agreement with observation, making use of the present Lord Rayleigh's data. This goes far to justify the hypothesis of molecular independence assumed by the theory. An important application of these formulæ lies in the re-determination of Avogadro's constant from observations on the extinction of solar radiation by the earth's atmosphere, correcting for molecular anisotropy and the probable variation in the proportions of its constituent gases above the stratosphere. Further observations over a wide range of pressure and temperature are desirable, especially in gaseous mixtures in gases capable of chemical combination and in gases near the critical point. The depolarisation is very sensitive to intermolecular influence as affecting complete independence of molecular orientations. This applies also to the effect on depolarisation of molecular aggregation, which, even in the case of a single gas, may be expected to give rise to an observable effect as the critical point is approached. Observations on light scattering in vapours in contact with their liquids would give some indications of molecular aggregation, and of circumstances of molecular collisions which determine peculiarities in the experimentally determined equation of state not interpretable in terms of the dynamical theory of gases. An invariant formula analogous to (1), based on Smoluchowski's theory of fluctuations of density, has been obtained for the scattering of light by dust-free liquids, and is in satisfactory agreement with Martin's observations. This will be dealt with in a future paper. G. A. S.

247. *Scattering of Light in Carbon Dioxide.* **C. V. Raman and K. R. Ramanathan.** (Roy. Soc., Proc. 104. pp. 357–368, Oct. 1, 1923.)—Experiments are described testing the light scattering produced in carbon dioxide under pressures ranging from 1 to 100 atmospheres, and temperatures from 0° C. to 50° C. Two methods of procedure are used. In the first, the substance is contained in small sealed spherical bulbs. In the second, a massive steel tube is used having a side window of plate glass to admit the incident beam and a similar end window for observation of the scattered beam. The other end of the tube is connected to a cylinder of carbon dioxide or to a pressure gauge. In both cases the apparatus is immersed in a water bath whose temperature can be varied at will. In the second case varying pressures are attained by immersing the cylinder in a water bath also, and dust is eliminated from the tube by repeated evacuation and re-admission of carbon dioxide. The intensity of scattered light is compared photometrically with that in a standard substance, and the state of its polarisation is observed quantitatively, using a double image prism. Ramanathan has worked out formulæ for the intensity and for the perfection of polarisation to be expected under different conditions assuming anisotropic molecules having three principal axes. Tables are given showing the agreement between the observed values and those calculated from this theory. The conclusions reached are: (1) The scattering in carbon dioxide in the condition of unsaturated vapour below the critical temperature is not proportional to the density, as inferred by [the present] Lord Rayleigh from his experiments, but increases much more rapidly as the saturation pressure is approached, and the polarisation of the transversely scattered light becomes sensibly more and more perfect. (2) The measurements in the saturated vapour and in the liquid phase in equilibrium with it show that when the liquid is further compressed by application of pressure in excess of the vapour tension, its light-scattering power shows a striking diminution, and the polarisation becomes markedly more imperfect. (3) Above the critical temperature the scattering power at first increases with rise of pressure, reaches a maximum, and diminishes again. (4) Except very close to the critical temperature, the experimental results agree well with the Einstein-Smoluchowski theory of scattering when account is taken of the anisotropy of the molecules [see Abstract 69 (1924)]. G. A. S.

248. *Machine Calculation of Rays through a Lens System.* **C. W. Woodworth.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 673–676, Aug., 1923.)—Describes methods of computing rays by machine operations, schemes being given by the aid of which the computations can be carried out by unskilled computers. The methods are explained by means of worked examples. J. W. T. W.

249. *Unit Magnification Surfaces of a Glass Ball.* **Alice Everett.** (Phil. Mag. 46. pp. 450–454, Sept., 1923.)—The unit surfaces of a lens are the loci traced by pairs of conjugate points for unit magnification on rays bound by some condition, such as passing through a fixed point. The nature of these surfaces for rays incident from a fixed point O on a solid glass sphere in air is investigated and is shown to be similar for different positions of O [see Abstract 71 (1924)]. G. A. S.

250. *Measurement of the Aberrations of a Microscope Objective.* **F. Twyman.** (Optical Society, Transactions, 24. 4. pp. 189–205; Discussion, 206–208, 1922–1923. Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 635–656, Aug., 1923.)—The author describes in detail the Hilger microscope interferometer, which is a development of the lens interferometer [see Abstract 830 (1922)]. If this instrument be provided with sufficiently delicate adjustments for focusing the objective under test (*i.e.* moving it to and from the mirror U in the diagrams) and for moving U laterally, it becomes immediately suitable for exhibiting the aberrations possessed by a microscope objective when it is focused to produce its real image at infinity. If, as is customary, the objective is intended to produce a real image at a *finite* distance, such a condition is simulated by the introduction of a negative lens R, corrected for spherical aberration, and called the tube length lens. This lens must give to the parallel beam a divergence exactly corresponding to the convergence of the beam which obtains in the intended use of the objective. A small drop of mercury (prepared according to a method described at the end of the paper) may be used as a convex mirror, but alternative arrangements have been devised for avoiding the necessity for a spherical mirror by comparing the objective to be tested with a second objective which is regarded as a standard. This is the arrangement shown in the diagrams. The details of construction of the instrument and its use in practice are fully described in the paper, which also contains a recipe for obtaining a transparent film of silver on glass. J. W. T. W.

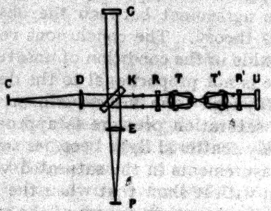


FIG. 1.

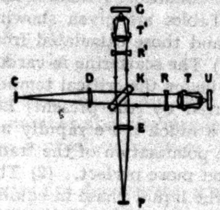


FIG. 2.

251. *Relation between Focal Length of Microscope Objectives and Number of Fringes seen in Convergent Polarised Light.* **F. I. G. Rawlins.** (Phil. Mag. 46. pp. 992–993, Nov., 1923.)—A continuation of previous work [see Abstract 1580 (1922)], giving the results obtained with crystalline plates cut at various orientations. The relation between the number of rings observed (N) and the focal length of the objective in mm. (F) is found to be $F = F_0 e^{-AN}$, the values of A for the different plates being given in the paper. J. W. T. W.

252. *The Molecular Scattering of Light in Mixtures of Carbon Bisulphide and Acetone.* **J. C. K. Rav.** (Phys. Rev. 22. pp. 78–84, July, 1923.)—The intensity of light scattered transverse to the primary beam by various dust-free mixtures is found to be much higher than is predicted by Einstein's formula which takes into consideration scattering due to concentration fluctuations alone, but to agree quantitatively with the stricter theory developed by C. V. Raman which takes into consideration also the scattering due to density fluctuations and the orientation scattering due to the anisotropy of the molecules. The polarisation of the transversely scattered light has also been determined and is found to agree with the formula given by Raman and Ramanathan. These results tend to confirm the Raman theory. AUTHOR.

253. *Theory of Optical Rotatory Power.* **R. de Mallemann.** (Comptes Rendus, 177. pp. 427–430, Aug. 13, 1923.)—The author has already [Abstract 2263 (1922)] derived an expression for optical rotatory power, containing a "rotational term," which he now omits, since he finds that it is possible to derive such an expression from the simple idea of molecular dissymetry. T. M. L.

254. *Short-Wave Radiation from Tungsten Filaments.* **M. Luckiesh, L. L. Holladay,** and **A. H. Taylor.** (Frank. Inst., J. 196. pp. 353–373, Sept., and pp. 495–519, Oct., 1923.)—An investigation to determine the change of actinicity of the radiation from incandescent tungsten with temperature of the tungsten, and to determine the decrease of the actinicity after traversing specimens of glass (chiefly those used in tungsten-filament lamp-bulbs). Spectral limits of glasses and lenses investigated. Methods mainly photographic, but partly visual. Revision of photographic nomenclature. Numerous tables and spectrophotographs. A. D.

255. *Theory of Light Quanta.* **H. Bateman.** (Phil. Mag. 46. pp. 977–991, Nov., 1923.)—The author considers the theory of W. H. Bragg that a form of electricity travels with the velocity of light and is responsible for the concentration of energy and momentum necessary in a light wave on the quantum theory. The author develops this conception mathematically and shows that the electric charges travelling with the waves may be regarded simply as convenient mathematical symbols for something which is quite compatible with the classical electromagnetic theory of light, the electric charges only appearing when a limiting process is carried out. J. W. T. W.

256. *Waves and Quanta.* **L. de Broglie.** (Comptes Rendus, 177. pp. 507–510, Sept. 10, 1923.)—This mathematical paper first arrives at the following result: The atom of light, equivalent on account of its total energy to a radiation of frequency ν, is the seat of a periodic internal phenomenon, which, seen by a fixed observer, has at each point of space the same phase as a wave of frequency ν propagated in the same direction with a speed sensibly equal (although very slightly superior) to the so-termed constant speed of light. The author then deals with the case of an electron describing a closed curve with a uniform speed sensibly lower than the velocity of light. The condition of stability derived is found to be that established by Bohr and Sommerfeld. When the speed varies along the trajectory, the Bohr-Einstein formula is obtained under certain conditions. Abstract 1275 (1919) should be consulted.

H. H. Ho.

257. *Light Quanta, Diffraction, and Interference.* **L. de Broglie.** (Comptes Rendus, 177. pp. 548–550, Sept. 24, 1923.)—The results of a previous paper [see preceding abstract] are first quoted for the case of a particle moving with velocity βc ($\beta < l$), where c is the velocity of light, which should be regarded as a wave propagated in the same direction with a speed $c/\beta = c^2/v$, the frequency of this wave being equal to the total energy of the particle divided by Planck's constant h. The speed

βc can then be considered as that of a group of waves of speeds c/β and frequencies $m_0c^2/h\sqrt{1-\beta^2}$. This result is then applied in a discussion of interference fringes and diffraction. H. H. Ho.

258. *Theory of Photographic Sensitivity.* **S. E. Sheppard** and **E. P. Wightman.** (Eastman Kodak Co. Research Lab. Comm. No. 185. Science, 58. pp. 89–91, Aug. 3, 1923.)—The very small amounts of substance involved in the formation of photographic latent images have prohibited conventional methods of chemical analysis. The ingenious attempt of P. P. Koch to apply the Ehrenhaft condenser method to the initial reaction of silver bromide in light has apparently not yet given unobjectionable results. But in any case, the use of gelatin-free silver halide cannot yet be regarded by the photographic chemist as significant for the gelatino-silver bromide of photographic emulsions. The generally accepted conclusion that the substance of the latent image in these consists of absorbed colloid silver has been reached by indirect methods, and is largely due to Lüppo-Cramer. In the present paper a brief description of the more recent contributions to the subject is given. A. E. G.

259. *Luminescence of Organo-Magnesium Halides.* **R. T. Dufford, S. Calvert,** and **Dorothy Nightingale.** (Am. Chem. Soc., J. 45. pp. 2058–2072, Sept., 1923.)—A wide range of substances of the type of Grignard reagents is examined for chemical luminescence and fluorescence. In all cases investigated, Grignard reagents in ether solution are chemically luminescent on oxidation by oxygen only if the Mg is attached directly to an unsaturated carbon atom. Increased speed of reaction brightens the emitted light, in agreement with the effect observed with the biologically derived luciferin [see Abstract 2160 (1923)]. The nature of the solvent affects the intensity of the luminescence, but apparently not the wave-length. No chemical luminescence is found when Zn or Hg is used instead of Mg. The wave-length and intensity of the radiation are affected by the nature of the reacting halogen. The wave-length and intensity are affected by the nature of the organic radical involved, and especially by the nature of substituted groups in the cyclic compounds. The effect depends on (*a*) the position of the substituent group; (*b*) the chemical nature of the substituent group. It is shown that the mass of the substituent is not the controlling factor. The luminescence of *p*-chlorophenylmagnesium bromide is believed to be the brightest yet recorded. Many Grignard compounds give light when treated with chloropicrin and with bromopicrin, but this light is not the same as that given out on oxidation with oxygen. A number of them, and especially their oxidation-products, are found to be fluorescent in ultra-violet light. A. B. C. L.

260. *The Phosphorescence Centre.* **A. Schleede.** (Zeits. f. Physik, 18. 2. pp. 109–112, 1923.)—When the capability of luminescence in a substance is joined with a storing up of the energy radiated into it which is only given up again gradually, the phenomenon is called phosphorescence. It is noticed that perhaps all inorganic substances with capacity for luminescence which were produced by a melting process show phosphorescence, whilst those produced by a means which avoids melting or by slow crystallisation from a solution exhibit luminescence but not phosphorescence. In the first case crystals are produced suddenly, and there must necessarily be caused disturbances of the lattice structure of the crystals. The author describes a working hypothesis which considers phosphorescence to be dependent on this crystalline or molecular deformation. In consequence of this the gradual dying away of phosphorescence may be supposed due to electrons loosened from the deformed molecule not being able to return at once to their stable paths but only when a heat vibration brings an atom again into its normal position relatively to its neighbouring atom. The same effects can be caused in organic substances by means which produce deformation of the molecule similar to that induced in inorganic crystals by sudden crystallisation. J. J. S.

261. *The Radiation Problem.* **J. H. Jeans.** (Phys. Soc., Proc. 35. pp. 222–224, Aug., 1923. Summary of the 8th Guthrie Lecture.)—It appears that physical and chemical transfers of radiation take place by quanta, while mechanical transfers take place according to the classical theory. It is probably only in the case of bound electrons that interchanges of energy can take place between an electron and a field of radiation. If we express the strength of the field as $X = X_0 + \Sigma X_p \cos pt$ where X_0 acts on the electron in the manner supposed by the classical laws, while the forces represented by X_p do not influence the electron at all except through cataclysmic motions of the kind contemplated in Bohr's theory; and if further we make X_p, etc., instead of measuring forces on electrons, to give an indication as to the probability of the occurrence of cataclysmic motion, then many of the present difficulties bid fair to be removed. There is then no longer any contradiction between the theory of quanta and the undulatory theory of light, and such phenomena as the photoelectric effect appear as the inevitable consequence jointly of the quantum equations and of Maxwell's equations for free ether. A. D.

262. *Spectroscopic Illumination with End-on Vacuum Tubes.* **T. R. Merton and R. C. Johnson.** (Phil. Mag. 46. pp. 448–449, Sept., 1923.)—For accurate determination of wave-lengths by micrometric measurements of spectra photographed in juxtaposition it is essential that the prism or grating be completely and uniformly illuminated. The difficulty of securing this is increased with end-on vacuum tubes. It can be shown theoretically that increased intensity and uniformity result from silvering the outer walls of the capillary. Photographs taken under suitable conditions are shown to verify this result. G. A. S.

263. *Wave-Length Standards in the Extreme Ultra-Violet.* **J. J. Hopfield and S. W. Leifson.** (Astrophys. J. 58. pp. 59–63, July, 1923.)—*Extreme ultra-violet spectra of hydrogen, oxygen, nitrogen, helium, and air.*—The wave-lengths of 37 strong lines between λ800 and λ1800 occurring in condensed discharge spectra of impure hydrogen, oxygen, nitrogen, helium, and air are determined, with a probable error of less than 0·1 Å., from photographs, on specially prepared ultra-violet films, taken with a Rowland concave grating having a radius of curvature of 50 cm. AUTHOR.

264. *The Origin of Spectra.* **J. C. McLennan.** (Engineering, 116. pp. 422–423, Oct. 5, 1923. Paper read before the British Assoc., Liverpool, 1923. Chem. News, 127. pp. 198–202, Sept. 28, and pp. 212–213, Oct. 5, 1923.)—A review of the present state of the Rutherford-Bohr theory of the atom, in its relation to the spectra of the elements, making use of the idea of stationary states of motion of the electrons, of Planck's quantum theory, the combination principle of Ritz, the determination of the energy levels by Moseley, Franck and Hertz, and McLennan, and the recent extensions of the theory by W. Wilson and Sommerfeld, in which the quantum idea is applied to momentum rather than to energy, and both the angular and radial momenta of the electrons are quantised. Mention is made of the principal quantum number of an orbit, n, of the additional quantum number, k, required to explain the fine lines of the hydrogen and other spectra, which defines the circular or elliptical shape of the orbit, and connotes a rotation of the perihelion of the orbit in its own plane; of the quantum number, j, required to explain doublets, triplets, and multiplets, and m for the resolution of a line by the magnetic field (Zeeman effect). The principle of selection of Rubinowicz and Sommerfeld, Bohr's correspondence principle, and his theory of the genesis of the atom by the binding of electrons in definite systems of orbits about the nucleus, are dealt with, and a table is given showing the distribution of the orbits for a number of elements. A diagram shows the relation between the different orbits of the hydrogen electron, in which n_k has the values 1_1, 2_1, 2_2, 3_1, 3_2, 3_3, 4_1, 4_2, 4_3, 4_4. Bohr's explanation of families of elements like the iron, rare earth and platinum groups is described, inner groups of electrons being built up, one by one, at these points in the periodic table, while the outer group remains unaltered, and the general chemical properties remain the same. The fine structure of the H-lines is ascribed by Sommerfeld to the variation of the mass of the electron with the speed, as required by the relativity theory. The resonance and ionising potentials of the elements are of great importance in the theory, measuring the work required to move an electron from orbit to orbit, or to infinity. The Kossel-Sommerfeld displacement law explains why the spark spectra of the alkali metals are similar in type to the arc spectra of the rare gases; since, when the valency electron is removed, the electronic configuration of the alkali metal is practically identical with that of its neighbouring rare gas. Ehrenfest has dealt with quantisation in space mathematically, and his results are confirmed by the experiments of Gerlach and Stern; the latter has shown that the atoms of a stream of silver vapour are separated by an electromagnet into two separate beams, indicating that all particles are either attracted or repelled by the magnet, that they all have a magnetic moment, and are axially oriented in space in the direction of the lines of force or in the opposite direction. Ehrenfest's adiabatic hypothesis of the Zeeman effect suggests that the Lorentz theory still remains applicable on the quantum theory. H. N. A.

265. *The Broadened Balmer Lines of Hydrogen.* **E. O. Hulbert.** (Phys. Rev. 22. pp. 24–36, July, 1923.)—The broadening of the Balmer lines of hydrogen by condensed discharges was investigated at various pressures from 48 to 250 mm. and the intensity distribution was determined for Hβ, Hγ, and Hδ by photographing the spectra through a neutral wedge. Reproductions of these photographs are given. A neutral wedge cell filled with an aqueous solution of a black dye was used as being more convenient to adjust than the ordinary neutral glass wedge. In each case the broadening was found to be symmetrical, amounting to about 60A for each line at 250 mm., but there was evidence of structure characteristic of each line. A quenched gap in series with the tube increased the broadening, while inductance decreased it. In mixtures with He or N_2 the broadening was the same as in hydrogen alone, at the same total pressure.

The Stark theory of broadening which relates it to the Stark effect of the electrical fields of the ionised atoms or the radiating atoms is given a mathematical form by assuming a probability law for the distribution of the atoms and ions and an inverse square law for the strength of the field, and introducing Sommerfeld's quantum expression for the Stark displacement. This gives $\log I_\lambda = \log [a/\lambda_0 - \lambda] - b/\lambda_0 - \lambda$, where $a = A\lambda\lambda_0 p^2 f$ and $b = B\lambda\lambda_0 p^{2/3} f$, f being a known function of the quantum numbers, and p the pressure in mm. of mercury. Comparison with experiment shows agreement as to the general form of the distribution curves. The great broadening produced by the condensed discharge thus appears to be due to the momentary hihg current density and corresponding large proportion of ionised atoms. J. J. S.

266. *Intensities in the Hydrogen Spectrum.* **A. L. Hughes** and **P. Lowe.** (Phys. Rev. 21. pp. 292–300, March, 1923.)—A three-electrode tube was used to show the changes in the intensities of the hydrogen lines with change of energy of impact of the exciting electrons. The voltage applied was from 29 to 110 volts, and the current and gas pressure were maintained constant, in order to preclude the simultaneous change of more than one variable. A long tube was used, and a long filament stretched in the direction of observation, in order to shorten exposures. The plate and grid were joined, in order to produce a space free of field. Intensities were determined by observing the density of the lines on a photographic plate with a microphotometer. H_α shows practically no variation over the range employed. H_β, H_γ, H_δ increase rapidly in intensity, and then more slowly, approaching constant values; the change was greater the higher the member. In the second spectrum, λλ6327, 6225, 6135, 6122, 6030 and 6018 decrease rapidly, while λλ5013, 4934, 4929, 4743, 4632, and 4205 reach a maximum of intensity between 30 volts and 40 volts and then grow feebler, but less rapidly than do the first group of lines. A. C. M.

267. *Intensities in the Helium Spectrum.* **A. L. Hughes** and **P. Lowe.** (Roy. Soc., Proc. 104. pp. 480–498, Nov. 1, 1923.)—Improved apparatus was employed, and the neutral-wedge method of comparing intensities was adopted; the energy of impact ranged from 34 to 110 v. It was shown that the intensity–energy of impact curve is characteristic of the series to which the lines belong. In the doublet system, the intensities decrease rapidly as the energy increases. The rate of decrease is greatest for $1\pi - m\sigma$ and least for $1\pi - m\delta$. The principal singlet series, $1S - mP$, increase greatly in intensity up to 80 v. and is thereafter constant. The diffuse singlets, $1P - mD$, show a maximum of intensity at 75 v., the rate of increase being greater the higher the member. The sharp singlets, $1P - mS$, rise slightly to 60 v. and then decrease a small amount [see preceding abstract]. A. C. M.

268. *The Optical Spectrum of Hafnium.* **H. M. Hansen** and **S. Werner.** (Nature, 112. pp. 618–619, Oct. 27, 1923.)—A pure hafnium preparation supplied by Hevesy and containing about 1 % zirconium in addition to traces of titanium, manganese, and niobium was used. Both arc and spark spectra were photographed, and a table of wave-lengths in I.A. for the region 2500 Å. to 3500 Å. with intensities for both spectra is given. The values have been compared with those given by Bardet for the arc spectrum between 2300 and 3500, differences of intensity indicating that his preparation was not very concentrated. The instrument and method of producing the arc spectrum were as previously described. The spark spectra were obtained with a large induction coil and carbon electrodes saturated with the hafnium salt solution. The wave-lengths are given to 0·05 Å. The results are to be extended to the remaining part of the spectrum. F. S.

269. *Spark Spectra of Lithium.* **E. v. Angerer.** (Zeits. f. Physik, 18. 2. pp. 113–119, 1923.)—An account of researches on the formation by various methods of the spectra of ionised lithium. J. J. S.

270. *Regularities in the Arc Spectrum of Titanium.* **C. C. Kiess** and **Harriet K. Kiess.** (Washington Acad. Sci., J. 13. pp. 270–275, July 19, 1923.)—Regularities of complex type that have been found to occur among the arc lines of titanium are described. A list of lines with wave-lengths arranged in groups of multiplets is given. The majority of the lines so far classified belong to King's temperature classes I and II, and are about 100 in number or very nearly 10 per cent. of the total recorded for the arc spectrum. The investigation is being continued. J. J. S.

271. *The Arc Spectrum of Terbium and a New Element of the Terbium Group.* **J. M. Eder.** (Akad. Wiss. Wien, Ber. 131. 2a. No. 3. pp. 199–298, 1922.)—The author has previously indicated the probability of the existence of a hitherto unknown element between terbium and dysprosium, which he has provisionally named *Welsium* after Carl Auer v. Welsbach, the investigator of the rare earths [Abstract 316 (1922)]. In the present paper a long list of several thousand lines in the arc spectrum of the terbium group and neighbouring fractions is given. These were obtained with the large concave grating previously used. No indication of the existence of a new element between gadolinium and terbium was found, but on comparing the lines of the various fractions groups of lines were noticed which appear in the intermediate fractions between terbium and dysprosium; these, however, are enfeebled in the middle chief fractions of terbium, and also on the other hand disappear or are weak in the dysprosium spectrum. These lines appear to belong neither to terbium nor dysprosium and furnish the justification of the author's hypothesis of the existence of the new element *Welsium*. Supported by his very extensive measurements of wave-lengths in the arc spectrum which reach from λ7257 to 2400 in the International System, he considers the existence of this element proved. The measurements also give a basis for the necessary further splitting-up of the assemblage of elements of the terbium group [see also Abstract 96 (1924)]. J. J. S.

272. *Series in Molybdenum Arc Spectrum.* **C. C. Kiess.** (Bureau of Standards, Sci. Papers No. 474. pp. 113–129, July, 1923.)—A continuation of previous work [see Abstract 1687 (1912)]. Regularities have been previously observed by Paulson and by Kiess and Meggers, consisting of constant frequency differences. These are now shown to form part of a regular series scheme. Narrow triplets, separations 121·5 and 87·0 form series $1\mathrm{S} - m\mathrm{P}_i$, $2\mathrm{P}_i - m\mathrm{S}$, and $2\mathrm{P}_i - m\mathrm{D}$. Wide triplets, separations 448·5 and 257·5, give $1s - mp_i$, $2p_i - ms$, and $2p_i - md$. Parallel to these last are $1s - (mp_i + k_i)$, $(2p_i - k_i) - ms$, and $(2p_i - k_i) - md_j$ with separations 379·9 and 233·4. The limits of the series have been calculated from Ritz formulæ, and from interseries combination lines. These give for the resonance and ionisation potentials, 3·25 v. and 7·35 v. respectively. Mention is made of Catalan's multiplets, and photographs are given. A. C. M.

273. *The Hydrogen Balmer Series and the Impossibility of Further Corrections to the Quantising of Hydrogenic Atoms.* **A. E. Ruark.** (Astrophys. J. 58. pp. 46–58, July, 1923.)—This paper contains the wave-lengths of the Balmer lines H_3 to H_{18} referred to tertiary iron standards in which only those lines are utilised which do not show appreciable pole effect and which are assigned the same wave-length by Burns, Meggers, Merrill, St. John, and Babcock. The plates from which the lines were measured were obtained by R. W. Wood, and the table hereby constructed and giving the values of λ from H_7 to H_{18} is claimed to be more accurate than any values previously given, although still not precise enough to yield a definitive value of the Rydberg constant R_H. Formulæ are therefore derived for calculating R_H from the wave-length of an unresolved Balmer line. The main components of H_3 are found to be separated by 0·0584 Å. The relativity correction only is needed to explain existing observations. (1) The observed structure of the lines does not admit a correction due to asphericity of nucleus or electron; Silberstein's theory shows that if the nucleus and electron have radii of about $3 \cdot 10^{-13}$ cm., the alteration of the lines would be unobservable. (2) H. A. Wilson's correction to the quantising of the atom, due to motion of a part of the potential energy with the electron, is not in accord with experiment. (3) H. S. Allen's formula for the correction due to a possible intrinsic magnetic moment of the nucleus is extended to the case of elliptic orbits; a magnetic moment of one Weiss magneton in the nuclei of H or He would distort the fine structure of H and He^+ lines by a readily observable amount, therefore it cannot exist. Reference is made to Wood's papers [see Abstracts 546 (1922) and 53 (1923)]. H. H. Ho.

274. *Width of Spectral Lines.* **G. Breit.** (Nat. Acad. Sci., Proc. 9. pp. 244–246, July, 1923.)—According to the classical wave theory, collisions among molecules of a luminous gas produce a spectral width of the lines emitted by the gas. The width considered is due to the fact that the Fourier analysis of a wave train involves a band of frequencies in the neighbourhood of the main frequency of the wave train. It is the purpose of this note to point out that according to the quantum theory a broadening of the lines is to be expected for the same reason and that the amounts of the broadening in the classical and in the quantum theories are nearly equal. J. J. S.

275. *Series-Spectra Involving more than One Electron.* **G. Wentzel.** (Phys. Zeits. 24. pp. 104–109, March 1, 1923.)—More than one electron may be necessary to explain complicated line-spectra. This suggestion is discussed and applied to the neon, alkaline earth (especially calcium), and chromium and manganese spectra. A. C. M.

276. *Spectral Lines in Electric and Magnetic Fields.* **N. Bohr.** (Phys. Soc., Proc. 35. pp. 275–302, Aug., 1923. The Seventh Guthrie Lecture.)—This is a survey of the principal features of the development of the explanation of the Zeeman and Stark effects on the basis of the quantum theory. The explanation provided by classical theory is considered, and is shown to be insufficient to account for the "anomalous" Zeeman effect, or for the direct proportionality of the Stark effect to the strength of the applied electric field. A short summary of the quantum theory of the hydrogen spectrum is given, followed by a deduction of the "state-relations" for periodic and multi-periodic motions. These are modified in accordance with the application of a magnetic and an electric field, first separately, and then simultaneously. Atoms containing more than one electron are thus dealt with, and it is shown that the displacement of the lines will be smaller, and vary as the second power of the electric forces. Mention is made of Landé's empirical rules for the number of components in the various spectral terms. A. C. M.

277. *Stark Effect for Strong Fields.* **A. M. Mosharrafa.** (Phil. Mag. 46. pp. 751–753, Nov., 1923.)—An extension of a previous communication [Abstract 685 (1923)] evoked by a letter of H. O. Newboult [Abstract 1864 (1923)]. See also Abstract 1611 (1922). A. C. M.

278. *Tesla Luminescence Spectra. Part III.* **W. H. McVicker, J. K. Marsh,** and **A. W. Stewart.** (Chem. Soc., J. 123. pp. 2147–2163, Sept., 1923.)—A continuation of previous work [see Abstract 1382 (1923)]. Changes of temperature and pressure have little effect on the spectra produced in the tesla-discharge; the spectra can therefore be taken as characteristic of the substance. Mono-derivatives of benzene were examined, and the spectra produced were characteristic of the groups present in the compound examined. Modifications have been made in the apparatus; rubber-glass joints have been eliminated; in using liquids of high boiling-point, a cell with a bulb at each end was used, the liquid being evaporated in one and condensed in the other. The quartz window is attached to the cell by amyl acetate "dope," protected by heat-resisting cement; this is a great source of weakness. Cyclohexane, toluene, ethylbenzene, benzyl alcohol, benzaldehyde, ethyl benzoate, benzonitrile, phenol, thiophenol, acetothenone, aniline, nitrobenzene, chlorobenzene benzyl chloride have been examined. A new series of bands, called the "blue series" is found in every compound examined having the structure $Ph\cdot C\vdots$, exceptions being benzonitrile and benzyl chloride. Increase in intensity of the blue series is accompanied by a diminution in intensity of the benzene part of the spectrum. Cyclohexane limits no spectrum, while a nitro-group, a chlorine atom, or the group $-CH_2Cl$ extinguish the spectrum. An alkyl group produces a blurring of the benzene system of bands; this blurring also occurs when an alkyl group replaces an hydrogen atom in benzaldehyde. The blue series cannot be considered as displaced benzene-group bands, since both exist together in the spectra of certain compounds, and the spectra are different in character. A. C. M.

279. *The Nature of the Röntgen Impulse.* **E. H. Kennard.** (Phys. Zeits. 24. pp. 372–374, Sept. 1, 1923.)—A theoretical discussion of a mathematical nature divided into two sections (1) General theory, (2) Use of experimental data. A. E. G.

280. *Pure Optical Resonance with X-Rays.* **G. Mie.** (Zeits. f. Physik, 18. 2. pp. 105–108, 1923.)—All the spectra obtained with the improved apparatus [see Abstract 1870 (1923)] are very complicated. It has not been possible to prove pure resonance of X-rays through selective reflection. It is therefore proposed to attempt the solution of the problem with other experimental methods. A. E. G.

281. *Influence of X-Rays on the Disruptive Discharge.* **G. Hammershaimb.** (Arch. des Sciences, 5. pp. 292–298, July–Aug., 1923.)—Before any definite conclusions can be arrived at it will be necessary to make a large number of experiments employing a perfectly constant source of X-rays and determining quantitatively the degree of ionisation of the gas under the action of rays for each pressure of the gas considered. The results obtained here between hemispherical electrodes 7,5 mm. radius, in the pressure limits 10 to 50 atmospheres of nitrogen, and at explosive distances 0,5 to 2,5 mm., are as follows. The relative lowering of the disruptive potential by X-rays of great intensity appears to be so much the more marked as the explosive distance is greater. For the same explosive distance the relative lowering of the explosive potential produced by the rays diminishes in proportion to the increase of pressure. Between certain limits of ionisation the disruptive potential remains practically constant. Beyond this limit, and in proportion as the hardness and intensity of the X-rays increase, the disruptive potential undergoes a more and more considerable lowering. It is suggested that by this means it may become possible to determine the hardness and intensity of X-rays when the lowering they produce on the disruptive potential is known.
A. E. G.

282. *Change in Wave-Length by Scattering.* **P. A. Ross.** (Nat. Acad. Sci., Proc. 9. pp. 246–248, July, 1923.)—A. H. Compton has shown that there is strong evidence of a change in frequency of X-rays and γ-rays, when scattered by paraffin, graphite, or aluminium. Theory indicates that the change in wave-length on scattering should be independent of the primary wave-length. The author has tested this conclusion by attempting to measure the shift for wave-lengths 0·708 Å. and 5461 Å. The change was looked for in the visible spectrum using a Lummer-Gehrcke interferometer of resolving power 360,000 and comparing the position of the fine structure of the green mercury line in a beam scattered at 180° from paraffin with the fine structure in a direct beam. The beams came from the same small arc and were brought into the plate by a comparison prism at the slit. No shift could be detected, although from the theory it should have been easily seen. Multiple reflections at nearly 180° between silvered glass surfaces were also tried with negative results. The shift of X-rays was measured using a photographic method. The scattered radiation shows a strong broad line shifted by about 0·025 Å., which agrees with theory and with Compton's results, and a fainter unshifted line not reported by Compton. The unshifted line is important since its explanation may account also for the absence of shift with visible light. The explanation of both may be that some electrons are closely attached to the massive nucleus and must scatter while nearly at rest.
J. J. S.

283. *On the X-Ray Spectra of Hafnium and Thulium.* **D. Coster.** (Phil. Mag. 46. pp. 956–963, Nov., 1923.)—This paper gives additional details of the methods used by the author and Hevesy in the discovery of hafnium, with complete tables of the wave-lengths of X-ray lines for hafnium. Bohr's theory shows that the element of atomic number 72 must be homologous to titanium, zirconium, and thorium; and as the elements in the neighbourhood of 72 (lanthanum, tantalum, tungsten) are very closely related to their homologues in the neighbourhood of zirconium (yttrium, niobium, molybdenum), it could be expected that element 72 would be closely related to zirconium. It was found by X-ray analysis that zirconium minerals contain 1 to 5 per cent. of an element of atomic number 72, in addition to zirconium, atomic number 40. The wave-lengths and intensities of the hafnium lines observed agree with those expected from the known lines of the elements Cp (71) and Ta (73). The method of quantitative analysis by comparison of the intensities of the lines of hafnium and tantalum is described, the observations of Dauvillier on certain lines of Urbain's supposed rare earth celtium, are discussed, and measurements of the wave-lengths of the L series of thulium (atomic number 69) are given. H. N. A.

RADIO-ACTIVITY.

284. *Phosphorescence of Minerals Coloured by Becquerel Rays.* **K. Przibram.** (Akad. Wiss. Wien, Ber. 130. 2a. No. 6. pp. 265–270, 1921.)—Kunzite, coloured green by Becquerel rays, phosphoresces after being exposed to arc light, while kunzite uncoloured, or decolorized by heating, does not. The phosphorescence is blue and red, not green. A similar but smaller effect is presented by fluor-spar. A. D.

285. *Radio-Active Disintegration Series and the Relation of Actinium to Uranium.* **A. S. Russell.** (Phil. Mag. 46. pp. 642–656, Oct., 1923.)—A preliminary account of this work has already appeared in Nature [see Abstract 1888 (1923)]. The object of the paper is to inquire how far existing data relating to the members of the three known disintegration series throw light on the subject as a whole and particularly on the relation of the actinium to the uranium series. In discussing analogies or general relations between the various series it has been found most advantageous to regard a series as made up of three types of successive changes. It is deduced that there are probably only four independent disintegration series, and the path of each of these is given. Simple empirical relations are given between the periods of bodies comprising an α-charge and between those comprising a β-charge. It is concluded that actinium arises from an isotope of uranium with an atomic weight of 239, present to the extent of about 5 %. Estimates are given of the periods of the bodies which precede proto-actinium in its series. Radioactive isotopes are compared with those of inactive elements, and a suggestion with regard to the existence of end-products other than those of lead are put forward. A. B. W.

286. *The Chemical Action of Penetrating Radium Radiation. Part XIV. The Action upon Oxalic Acid, Potassium Tetra-Oxalate and Potassium Chlorate.* **A. Kailan.** (Akad. Wiss. Wien, Ber. 130. 2a. No. 9–10. pp. 469–480, 1921.)—The author gives data regarding a series of experiments upon 1 % aqueous solutions of oxalic acid submitted to radium radiation, over a long period of hours, or submitted to ultra-violet light, with or without in each case uranium nitrate as a catalyser. The chief reaction is COOH·COOH=HCOOH + CO_2, but secondary reactions resulting in aldehyde or CO_2 and H_2O can occur under certain conditions, and differences may occur according as to whether the end products are estimated by acidimetric or oxymetric methods. The reactions are discussed from the point of view of physical chemistry as to velocity of reaction, type of reaction (mono- or bi-molecular, etc.), etc. A similar series of experiments are then detailed for the decomposition of potassium tetra-oxalate under radium radiation and ultra-violet light, with and without the above catalyser. Final sections treat of the reduction of $KClO_4$ to KCl under the action of radium and ultra-violet light from similar standpoints. The paper consists throughout of experimental data given in great detail and incapable of brief abstraction. No general conclusions are drawn. B. J. L.

287. *A Method for Photographing the Disintegration of an Atom and a New Type of Rays.* **W. D. Harkins** and **R. W. Ryan.** (Am. Chem. Soc., J. 45. pp. 2095–2107, Sept., 1923.)—The authors have taken 21,000 photographs of α-ray tracks in air and a few in helium and ethyl chloride with a modified Shimizu-Wilson apparatus, the motion camera employed being provided with a driving mechanism and an optical system such as to take views from two directions at right angles to one another at the end of each expansion. ThC, ThC′, and RaC were used as sources of α-rays and 80,000 tracks were photographed in air. In all about 12 billion atoms were shot through and in three cases only was the nucleus of the atom of the gas hit sharply enough to give a retrograde motion to the α-particle after the collision. From this it is concluded that the radius of the nucleus of an atom of nitrogen or oxygen is of the order of 10^{-13} cm. The rarity of a collision between high-speed α-particles and the nucleus of an atom through which it passes, increases greatly as the directness of the collision increases. The characteristics of an ordinary collision are: (1) The initial track splits into two branches, the one branch being the track of the projected nucleus and the other the track of the rebounding α-particle; (2) momentum is conserved in the collision; and (3) the three tracks lie in one plane. If the bombarded nitrogen or oxygen nucleus is disintegrated four tracks are visible, the fourth track being due to a fragment such as an electron, a hydrogen, or a helium nucleus disrupted from the bombarded nucleus. The chance of such a disintegration increases rapidly with the directness of the collision and with the speed of the α-particle.

Rays of a new type designated as zeta (ζ) rays are described. It seems probable that these rays are due to electron emission. The particles are very light since the direction of the α-particle is not materially affected by the emission and their tracks are much longer than those of δ-rays.

The work is being extended to test experimentally the stability of atom nuclei. The difficulty of the method lies in the small number of direct hits obtained. Less direct impacts are relatively numerous. In no case has any one of these oblique impacts affected a disintegration of the nucleus. A photograph taken with argon in the expansion chamber shows that the argon nucleus remains intact even under the sharp impact of an α-particle from ThC.′ E. A. O.

HEAT.

288. *A Laboratory Optical Pyrometer.* **W. Schriever.** (Iowa Acad. Sci., Proc. 23. pp. 69–82, 1921.)—This paper gives a detailed description of a disappearing-filament type pyrometer suitable for laboratory use.
E. G.

289. *A Simple Method of Spectral Temperature Measurement.* **F. Patzelt.** (Zeits. f. Physik, 15. 6. pp. 409–412, 1923.)—In continuation of the work referred to in Abstract 948 (1923), the author describes a simple form of spectral pyrometer of the disappearing filament type, which he has used for observing the temperature of the positive crater of the carbon arc.
E. G.

290. *Heats of Vaporisation of Mercury and Cadmium.* **M. F. Fogler** with **W. H. Rodebush.** (Am. Chem. Soc., J. 45. pp. 2080–2090, Sept., 1923.)—To test the generalisations regarding the entropies of monatomic gas a direct determination of the heat of vaporisation of mercury was undertaken. In principle the method employed consists in determining the difference in the rate of input of electrical energy required to maintain a quantity of liquid in an insulated vessel at constant temperature when vaporising at a measured rate and when no distillation occurs. The vaporisation was controlled by distilling the mercury in a closed system maintained at constant pressure. When it was desired to commence the distillation, the pressure was lowered until the mercury just began to vaporise; distillation was stopped by admitting gas and raising the pressure. The vessel containing the mercury to be distilled was placed in a Dewar tube which was enclosed in a vapour bath of di-butyl ether, which boils at 142°.

The heat of vaporisation of mercury is found to be 14490 ± 50 calories at 142° C. If this value be corrected to 298° K. we obtain 14,670. The value obtained by differentiating the empirical equation of Smith and Menzies at 298° K. is 14615 cal. The heat of vaporisation of cadmium was obtained by the indirect method. The boiling-point at different pressures was determined. The calculated heat of vaporisation of cadmium is found to be 25,350 ± 100 cal. at 594·1° K. The data are in accord with the calculations, based on the quantum theory, of the entropies of the monatomic gases. [See also Abstracts 2112 (1922) and 1688 (1923).]
E. G.

291. *Vapour Pressures and Crystal Structure of the Halogen Hydrides.* **F. A. Henglein.** (Zeits. f. Physik, 18. 1. pp. 64–69, 1923.)—The results are given of the measurement of vapour pressures of HCl (solid), HBr (solid), HBr (liquid), and HI (solid). Deductions with respect to the crystal structure of the solid hydrogen hydrides may now be drawn from the thermal data. Heat of fusion and melting-point increase with rising atomic weight of the halogen in the case of the homoiopolar combinations Cl, Br, I, which possess a molecular lattice; in the case of the heteropolar combinations with ionic lattice (KCl, KBr, KI) the melting-point and consequently also the heat of fusion decrease with rising atomic weight of the halogen ion, if the kation remains the same. As regards the halogen hydrides, the melting-points likewise rise with the molecular weight, so the heat of fusion of HCl is smaller than that of HBr; for HI (solid) a molar heat of fusion of about 700 cal. would have been expected, yet it amounts to only 170 cal. From that the following consequences are drawn: (1) The solid halogen hydrides form a molecule lattice as chlorine—bromine—iodine. (2) HI possesses before its melting-point another crystal form, like HCl and HBr. It is possible that HI at lower temperatures forms a second modification, as already in the case of iodine likewise two modifications are observed. The author has previously commented on the close connection between halogens and halogen hydrides, and has shown that the following ratio holds:

$$\frac{\text{Molecular volume of the halogen at the boiling-point}}{\text{Molecular volume of the halogen hydride at the boiling-point}} = 1 \cdot 47.$$

The following summary of the sublimation pressures at the melting-point serves to characterise the molecule and ion lattices.

	Molecule Lattice.						Ion Lattice.		
	Cl.	Br.	I.	HCl.	HBr.	HI.	KCl.	KBr.	KI.
Vapour pressure at the melting-point, mm. Hg.	8·9	44·1	87·0	125·2	224·2	369	about 0·4		

J. J. S

292. *On the Theory of the Temperature Variation of the Specific Hea of Hydrogen.* **E. C. Kemble and J. H. van Vleck.** (Phys. Rev. 21. pp. 653–661, June, 1923.)—The purpose of the present paper is to present a corrected calculation of the rotational and vibrational specific heat of an elastic non-gyroscopic model of a diatomic gas. Such a calculation is desirable, since the observed specific heat of hydrogen at high temperatures is appreciably greater than the limiting theoretical value for rigid molecules, (5/2) R or 4·963 cal. per mol. To account for the abnormally large specific heat of hydrogen at high temperatures, the molecule is assumed to have an internal vibrational degree of freedom. Assuming a dumb-bell model and the following law of force $F = a(r - r_0)/r^3$, the energies of the stationary states are derived on the basis of the Bohr-Sommerfeld form of the quantum hypothesis, and an expression for the specific heat obtained. When suitable values of the two adjustable constants are chosen, satisfactory agreement is obtained with the experimental results for hydrogen throughout the entire range, to 1300° K. The constants of the hydrogen molecule, computed from the empirical constants of the specific heat equation are: Nuclear spacing, $0 \cdot 488 \times 10^{-8}$ cm.; moment of inertia, $1 \cdot 975 \times 10^{-41}$ gm. cm.^{2}; wave-length corresponding to normal vibration, $2 \cdot 05\,\mu$. New empirical formulæ between 300° and 2300° K. are derived from Pier's data for the specific heats of hydrogen and water-vapour, *viz.*:

$$C_v = 4 \cdot 87 + 0 \cdot 539 \times 10^{-3}t + 0 \cdot 146 \times 10^{-6}t^2$$

and $$C_v = 6 \cdot 03 + 4 \cdot 2 \times 10^{-3}t - 4 \cdot 07 \times 10^{-6}t^2 + 1 \cdot 95 \times 10^{-9}t^3$$

respectively. Calculation on the same basis from the observations by Scheel and Heuse on nitrogen, oxygen, and carbon monoxide near 92° K. give results which show that either the assumed specific heats are wrong or that the theory is not applicable to these gases. H. H. Ho

SOUND.

293. *Lissajous' Whistling Flame.* **E. G. Richardson.** (Am. J. Sci. 6. pp. 11–14, July, 1923.)—An examination of the phenomenon attributed to Lissajous in which the air in an open tube may be made to sound by placing the mouth of the tube over the flame produced when gas from a Bunsen burner is lighted above a piece of copper gauze. The author finds that the flame from a Méker burner will act in the same way. The phase relation between the vibration of the flame and the stationary air-waves in the pipe is determined by the same method used by the author in the study of the singing flame [see Abstract 122 (1924)]. It is found that the body of the flame does not vibrate; the periodic variation is in the blue part at the base. The experiments show that the air-supply to the flame plays an important part, that the action of the grid is to cool the flame rapidly between each of its hot periods, and that a draught of air through the tube, as postulated by Gill, is not essential. The action depends mainly, as Gill stated, on varying currents through the gauze, rather than on pressure changes as in the ordinary singing flame. The to-and-fro motion of the air in the pipe, due to stationary waves, reacts on the air-supply to the flame, causing a variation in the quantity of heat transferred per second to the vibrating air column. The flame is shown to be in a position to transfer a greater amount of heat just before a condensation occurs, which corresponds to the condition deduced by Rayleigh for the maintenance of such vibrations by heat. T. H.

294. *The Dynamical Theory of the Bridge of a Certain Class of Stringed Instruments.* **K. C. Kar.** (Phys. Rev. 21. pp. 695–698, June, 1923.)—The effect of letting a vibrating string strike a sharp edge near one end, as in the case of the Indian plucked instrument tanpura, is to increase the relative intensity of the octave and other even harmonics, while the rest diminish quickly almost to nothing, giving a peculiar sweet note. The *mathematical theory* is developed. The phenomenon apparently violates the Young-Helmholtz law since it may be observed even when the string is plucked in the middle; but the effect of the sharp edge is to build up the even harmonics even if they are very weak in the original vibration. AUTHOR.

295. *Measurement of Sound Intensity.* **J. C. Karcher.** (Bureau of Standards, Sci. Papers No. 473. pp. 105–111, May, 1923.)—A sound-detecting device, such as a magnetophone or electrostatic transmitter, and two coils whose mutual inductance can be varied by known amounts constitute a measuring instrument. The sound detector and one coil are connected to an indicating instrument, consisting of a vacuum-tube amplifier, a rectifier, and galvanometer. The e.m.f. generated in the detecting instrument is compared by substitution with the e.m.f. generated in one coil when the other carries a known current. Since the sound intensity is proportional to the square of the e.m.f. generated in the detector, a means of making sound intensity measurements is presented. The necessity for the calibration of an amplifier is obviated. The instrument has a sensitivity range of about a million fold, the lower limit being near the threshold value of audibility. Absolute standardisation of the apparatus may be effected by comparison with a Rayleigh disc or by the use of a thermophone. The paper includes a diagram of the apparatus and a graph of its calibration curve. E. H. B.

296. *Simple Device for Recording Sound Waves.* **C. J. Lapp.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 661–664, Aug., 1923.)—This sensitive device is similar in principle to the phonodeik of D. C. Miller. The optical system is, however, simpler. A diaphragm of dermatype paper (taken from dermatype stencils for the Edison-Dick mimeograph) is stretched over a two-inch circular opening in a brass plate 0·159 cm. thick and held in place by a flat brass ring of same thickness screwed to the plate. To the centre of the diaphragm are attached perpendicularly four or five silk fibres, the other ends of which are held by a very fine conical aperiodic spring attached to the end of a bracket mounted on the brass plate. An oscillograph mirror 0·154 cm. long and 0·0435 cm. wide is mounted with its plane parallel to that of the diaphragm, one end being attached by shellac to the fibres already mentioned, and the other end carried by a tight single silk strand (of a three-strand silk thread) passing across the diaphragm 0·476 cm. above and parallel to it. Light through a pin hole from an arc is focused on the mirror and then by a cylindrical lens on to a moving plate. Seven photographic reproductions are given of vibrations, some from organ pipes, some from pipes and C. T. Knipp's singing tube giving beats, and one from the French horn. E. H. B.

297. *Overtones of Large Tuning Forks.* **S. H. Anderson.** (Phys. Rev. 21. pp. 692–694, June, 1923.)—Elimination of the first overtone, frequency 6·27 times the fundamental, which is usually very prominent for forks of pitch below 256 d.v./sec., can be secured by striking the fork with a soft, padded hammer at the internal node, situated one-fifth the length of the prong from the free end, and at the same time holding the fork lightly at the antinode, situated two-fifths the length of the prong from the fixed end. The elimination of this overtone has make it possible to detect a new overtone whose frequency is approximately three times that of the fundamental. This tone seems to be due to the vibration of the fork as an unsymmetrical free-free bar with one internal node 0·37 the length of the prong from the outer end and antinodes at the tips of the prongs and the tip of the stem. AUTHOR.

298. *Amplitudes of Hewlett Tone Generator.* **C. E. Laue.** (Iowa Acad. Sci., Proc. 28. pp. 83–88, 1921.)—The tone generator designed by C. W. Hewlett (Phys. Rev. 17. p. 257) is intended for use as a precision source of sound. Its operation has been investigated mathematically by its designer and a method given for calculating the amplitude of vibration of its diaphragm from the electrical input. The present paper describes a method by which actual measurements of the amplitude may be taken for comparison with the calculated amplitudes. For this purpose an electrical micrometer was made and operated on the same principle as that described by P. E. Shaw [Abstract 1779 (1905)]. These measured values of amplitude agree as well as might be expected with the calculated values. It is thus concluded that the method provided by Hewlett for the calculation of amplitudes will give them nearly enough for practical purposes. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

299. *Interior and Exterior Space-Time Forms of the Poincaré Electron in Weyl's Geometry.* **J. Marshall.** (Roy. Soc. Edinburgh, Proc. **43. 2.** pp. 170–179, 1922–1923.)—Weyl's relativity theory is applied to the case of an isolated sphere with a uniform surface distribution of electricity, and a solution obtained which points to the existence of a mechanical force, arising from the metrical groundwork, acting inwards on the electron. This force, it is suggested, may be the non-Maxwellian cohesive force necessary to prevent the disruption of the electron.

The work is based on the field equations:

$$-\chi T^{\nu}_{\mu} = G^{\nu}_{\mu} - \tfrac{1}{2}g^{\nu}_{\mu}(G - 2\lambda) \text{ and } \lambda g_{\mu\nu} = G_{\mu\nu} + H_{\mu\nu}$$

(where $H_{\mu\nu}$ is a certain linear expression in the potentials, ϕ_{μ}, and their derivatives): equations which become identical with Weyl's integrals derived from his action principle on using the relation $\phi^{\alpha}_{\alpha} = 0$. To obtain the boundary conditions the fictitious field in the " interior of the electron " is first examined, by setting $\phi_1 = \phi_2 = \phi_3 = 0$, $\phi_4 =$ a constant $= \phi_0$; and a form approximating to Minkowski's is found for ds^2, together with the gauging equation $\lambda = 0$, which may be interpreted to mean that actual measurement within the electron is impossible. The exterior space form ($\phi_1 = \phi_2 = \phi_3 = 0$, but ϕ_4 varying from point to point) can now be determined. The result is:

$$ds^2 = -\frac{u\,du^2}{\xi(1 + u^2/b^2)} - u^2(d\theta^2 + \sin^2\theta\, d\phi^2) + \frac{\xi c^2 dt^2}{u}$$

where u is a function of r containing the constant of integration b, but no other physical constants, and is such that, for large values of b, $r = u(1 - u^2/10b^2 + O(u^4/b^4))$. ξ is a function of u, b, λ, and of a, the radius of the Electron. From Maxwell's equation $F^{\mu\nu}_{\nu} = J_{\mu}$ the gauging equation is found to be $\lambda = \frac{1}{u^2}$, and ξ then reduces to $c\sqrt{u^2 + b^2}$. κ, the electrostatic potential is $-e/u(1 + u^2/b^2)^{\frac{1}{2}}$. In order, then, that $\kappa \sim -e/u$ for large u, b must be large compared with the radius of the universe. The value of the force acting inward on the electron can now be estimated and is given by $qc^2/\chi ab$, where q is a number between 0·7 and 0·9. On inserting the values of the other constants, which are all known except b, it is found that this pressure is equal to that required to hold the electron together if $b = O(10^{29}$ cm.), a value not in conflict with the minimum radius to be ascribed to the stellar universe on astronomical grounds, namely 10^{25} cm. M. H. A. N.

300. *Magnetic Force Produced by a Circular Electric Current at a Point in the Interior of the Circuit.* **E. Mathy.** (J. de Physique et le Radium, **4.** pp. 240–245, July, 1923.)—The treatment is mathematical, being based on the development of Laplace's formula. A. B. C. L.

301. *The Views of Carl Hering on Electromagnetic Laws.* **L. Brüninghaus.** (Rev. Gén. d'Él. 14. pp. 250–252, Aug. 25, 1923.)—The author deals critically with certain experiments described by C. Hering as conflicting with the usually stated laws of electromagnetism [see Abstract 1455 (1923)] and reaches the conclusion that these laws are nevertheless correct. W. R. C.

302. *The Braking of Moving Charges by Passage over Conducting Bodies.* **W. P. Radt.** (Ann. d. Physik, 72. 5. pp. 400–420, Sept. 28, 1923.)—Section 1 of this paper describes an Hertz experiment in which two rectangular copper discs attached at the ends of a horizontal needle oscillate over a conducting glass disc. The needle by means of a wire attachment was made to execute torsional vibrations, and Hertz observed an increase in the damping effect when the discs were electrified. Further work in this direction appears not to have been done, and the present author now investigates this braking effect with the aid of Maxwell's theory. Sections 2, 3, and 4 deal with the generation of the electric field by potentials, the form of the potentials and the boundary conditions, and the behaviour of the induced charges. Section 5 then considers the braking force for rectangular and Section 6 for point charges. The integration of the equation of motion is carried out in Section 7, while Section 8 discusses the force perpendicular to the conducting surface. Section 9 is devoted to the consideration of plates of finite thickness, and Section 10 to point charges which fly through a hollow cylinder. In Section 11 numerical calculations are made for kathode-ray particles of $q = 10^9$ cm./sec.$^{-1}$. The final section discusses the possibility of experimental proof of the theoretical results by means of electrons (kathode rays). The paper is mathematical throughout. H. H. Ho.

303. *Electric Figures.* **Elisabeth Kara-Michailova.** (Akad. Wiss. Wien, Ber. 131. 2a. No. 3. pp. 155–169, 1922.)—On plates of gypsum, previously dusted or dusted afterwards, the elliptical figures dilate with increasing tensions, but the form becomes, with positive figures, more nearly circular. On previously dusted plates the ellipse is nearly a circle. At high tensions subsidiary bundles appear, the negative along the long axis of the ellipse (the direction of minimum dielectric constant), the positive at right angles to this on gypsum, but not distinct on other anisotropic substances. The radius depends on the nature of the substance, being greater the smaller the dielectric constant. A. D.

DISCHARGE AND OSCILLATIONS.

304. *Ionic Oscillations in the Striated Glow Discharge.* **R. Whiddington.** (Phil. Mag. 46. p. 720, Oct., 1923.)—Referring to the paper by Appleton and West [see Abstract 1656 (1923)] the author points out that the discontinuous nature of the vacuum-tube discharge had already been observed by Cantor, Rieche, and others. W. R. C.

305. *The Normal Kathode Fall and the Photoelectric Sensitiveness of some Metallic Sulphides and Metallic Oxides.* **B. Aulenkamp.** (Zeits. f. Physik, 18. 1. pp. 70–74, 1923.)—These two phenomena depend on many surrounding conditions and the true connection between the two is yet far from being known. The author has determined the normal kathode-fall and the photoelectric sensitiveness of a series of sulphides and oxides and has found that with preparations produced under similar conditions there is a parallelism between the two phenomena. J. J. S.

306. *Note on the Striking Potential necessary to Produce a Persistent Arc in Vacuum.* **F. Simeon.** (Phil. Mag. 46. pp. 816–819, Nov., 1923.)—The arc in vacuo is found to be intermittent when the voltage available for striking is of the order of 100–200 volts, while radiations are emitted corresponding to the spark lines of the element in question. The present paper records some experiments on the spectrum of carbon in vacuum, and its appearance when the applied voltage has several values. For 40 volts or more the arc was as persistent as in air, but, when reduced to 30 volts the arc no longer persisted, a momentary flash only being produced when the electrodes were slightly separated after touching, the appearance being similar to that obtained with two copper electrodes for a striking potential of 220 volts. A marked change in the spectrum of the arc occurred simultaneously, however, with the change in appearance. A striking potential of 40 volts was sufficient to excite the complete spectrum as given by 220 volts, including the lines near 385A, identified by Millikan [see Abstract 1421 (1920)] as the $L\alpha$ lines of carbon; but with 30 volts the $L\alpha$ and some associated lines were suppressed, still leaving, however, a number of recognised spark lines—*e.g.* 2297, 2509, and 2512A. This shows that the lower potential is sufficient to ionise carbon atoms by removal of one of the outer electrons, but insufficient to excite radiation corresponding to the L levels. To test whether there is a connection between L-radiation and the persistence of the arc in vacuo, arcs were formed with Cu, Al, Si, and Na, the calculated values being found in good accord with those observed. The results are compared with corresponding ones for an arc in air at ordinary pressures. In air, however, the nature of the electrodes does not appear to be of importance as regards the voltage required to establish an arc, which depends chiefly on the atmosphere in which it is formed, while it seems unnecessary to excite the L-series of the gases in the atmosphere. H. H. Ho.

307. *Demonstration of Charges of Metallic Vapours in Arc Light.* **A. Salb.** (Phys. Zeits. 24. pp. 374–375, Sept. 1, 1923.)—The researches of Lenard [see Abstract 1735 (1905)] indicated that the metallic vapour originating at the electrodes of arc lights carry for the most part positive electric charges. It was therefore, as Lenard showed, vapour developed at the positive electrode and conveyed towards the negative electrode by the electric field, while the vapour originating at the negative pole is driven back to that pole by the action of the same field. On this account the light from the metallic vapour which comes from the positive electrode fills practically the whole space between the two electrodes, while that from the negative electrode is limited to the immediate surroundings of that electrode. In this paper a method of demonstrating this phenomenon to a large audience is described and diagrams of the structure of the arc-light portion of the apparatus are given. A. E. G.

308. *Counter Electromotive Force in Electric Arc.* **A. Hagenbach** and **M. Wehrli.** (Arch. des Sciences, 5. pp. 302–305, July–Aug., 1923. Paper read before the Soc. Suisse de Physique.)—A simplified method of measurement. Duddell's measurements for homogeneous carbons confirmed.

Details given for other cases (mercury lamp, etc.). The electromotive force decreases as the anode-fall becomes smaller. [See Abstract 730 (1923).] A. D.

309. *The Deflection of a Stream of Electrons by Electromagnetic Radiation.* **E. O. Hulburt.** (Phys. Rev. 21. pp. 650–652, June, 1923.)—A theoretical calculation, based on classical electrodynamics, gives for the maximum angular deflection, when certain approximations are made, $He/m\omega$, where $\omega/2\pi$ is the frequency of the radiation, and H is the field due to it. For sunlight ($H = 0{\cdot}04$), the value is only 4×10^{-10}, far too small to detect experimentally, while for intense X-rays, the value is of the order of 10^{-13}. Recently C. J. Lapp reported having obtained an observable deflection with X-rays. If further research should confirm this result, it would appear to be in direct conflict with the classical theory. AUTHOR.

310. *Electron Emission from Metals as a Function of Temperature.* **S. Dushman.** (Phys. Rev. 21. pp. 623–636, June, 1923.)—The emission of electrons from a metal may be considered as thermodynamically equivalent to the evaporation of a monatomic gas, for which an equation is derived on the basis of the Nernst heat theorem. If it is assumed that the specific heat of free electrons in the metal is negligible while the specific heat of the evaporated electrons is the same as that of a monatomic gas, the equation assumes the simple form $I = AT^2\epsilon^{-b_0/T}$ where $b_0 = \phi_0 e/k$, e being the electronic charge, k the Boltzmann constant, and $\phi_0 = \phi - 3/2kT/e$, where ϕ is the Richardson work function. An equation of this form has been suggested before, but not on the same theoretical grounds, and a different value of A has been obtained. Its chief advantage over the usual Richardson equation $I = A_1T^{1/2}\epsilon^{-b/T}$, where $b = \phi e/k$, is that A is theoretically a universal constant. The value of the universal emission constant A is computed in two ways. Using the Sackur-Tetrode equation for the chemical constant i_0, A comes out at 60·2 amp./cm.^{2} deg.^{2}, while the theory of rational units of Lewis, Gibson, and Latimer gives 50·2 amp./cm.^{2} deg.^{2}. Recent experimental results of Davisson and Germer, and of Schlichter, as well as data obtained by the writer, agree with the new equation as well or better than with the old, but the temperature scale is not sufficiently known to distinguish experimentally between the two values of A. The relation between A and the chemical constant i_0 (or C_0) is derived. Values of the work function in equivalent volts have been computed from the experimentally determined values of b_0 for tungsten (4·53), thorium (2·94), molybdenum (4·31), tantalum (4·40), and calcium (2·24) within ½ to 1 per cent. The values for uranium (3·28), zirconium (3·28), yttrium (3·19), and cerium (3·07) are upper limits. In general, the values are lower the larger the atomic volumes. Experimental details will be given later. A. E. G.

311. *Scattering of Electrons by a Positive Nucleus of Limited Field.* **C. Davisson.** (Phys. Rev. 21. pp. 637–649, June, 1923.)—A theoretical paper in which the angular distribution of electrons scattered by a positive nucleus of limited field is considered. It is shown that if a random distribution of electrons moving on parallel lines with a common velocity, corresponding to V volts, is projected into a central field of force given by E/r^2 for values of $r < p$ and by zero for $r > p$, the intensity of scattering in a direction making an angle ψ with the incident beam will be proportional to $\{(2\mu - 1)/[(2\mu - 1)^2(1 + \cos\psi) + (1 - \cos\psi)]\}^2$, where $\mu = Vp/E$, provided the variation in mass of the electron with speed is disregarded. Allowing for variation of mass of the electrons with speed so that the trajectories of the electrons through the limited field conform to the orbits calculated by C. G. Darwin, the distribution patterns will depart considerably from those calculated on the simple theory, particularly for small values of V. Semi-graphical methods are developed for constructing the distribution curves when V, p, and E are given. Taking into account the mutual energy of electron and nucleus according to the view suggested recently by H. A. Wilson, the actual scattering patterns may be expected to conform closely to those calculated on the simple theory. A. E. G.

312. *Emission of Electrons from Metals in High Fields.* **G. Hoffmann.** (Phys. Zeits. 24. pp. 109–111, March 1, 1923.)—A summary of investigations made by the author [Abstract 1922 (1921)] and by F. Rother [Abstract 341 (1915)]. It is suggested that the latter's results have to deal with a poorly conducting layer. The author shows that when the strength of the field between two metals in a vacuum is increased, a current commences when a critical potential is reached which depends upon the metal employed, *e.g.* for platinum it is about $4 \cdot 10$ volts per cm. The phenomenon is explained on the basis of removal of electrons from the metal. A. C. M.

313. *Critical Electron Energies in Hydrogen.* **F. Horton** and **Ann C. Davies.** (Phil. Mag. 46. pp. 872–896, Nov., 1923.)—The authors have previously [see Abstract 718 (1920)] given an account of an investigation of critical electron energy values in hydrogen. They then described experiments made to ascertain whether the positive ions which could be detected leaving a positively charged platinum surface under electronic bombardment could be attributed to hydrogen occluded in the metal, but the results afforded no support for such a view. From the experiments in hydrogen it was concluded that there are 2 critical electron energies at which radiation is produced, and 2 at which ionisation occurs, and from the approximate agreement between the values obtained and those predicted from Bohr's theory, the first radiation voltage and the first ionisation voltage were attributed to the hydrogen atom, and the other 2 critical values to the hydrogen molecule. It was assumed previously that at the higher ionisation voltage the molecules are dissociated into pairs of atoms and that one atom of each pair is ionised, but the determination of the absolute values of critical points was then only approximate. The new methods used for testing the origin of a radiation were to ascertain whether it could be absorbed and re-emitted by the gas in its normal state, and were carried out by finding whether the radiation would travel through the gas and produce a photoelectric effect on an electrode so placed that it could not be illuminated either directly, or by reflection, from the position at which the exciting electron collisions occurred. As hydrogen in the normal state is molecular, such a "handing-on" of radiation cannot occur if the radiation is produced by dissociation of the molecule into atoms and the excitation of one of these atoms, but only if of true molecular origin. The test of the nature of the positive ions produced at a critical ionisation stage was a spectroscopic examination of the radiation produced when recombination occurs, the assumption being made that Balmer lines are due to the recombination of electrons and positive hydrogen atoms, and that they therefore only appear if atoms are present. Olmstead's recent experiments are described and discussed, also those of Duffendack. The present experiments have indicated that the following voltages correspond to critical energy values in hydrogen: 10·2, 11·9, 12·6, 13·5, 15·9, 22·8, 26·1, and 29·4. At 10·2, 11·9, 12·6, and 26·1 an increased production of radiation commences, while at 13·5, 15·9, and 29·4 an increased rate of production of ionisation is initiated. At 22·8 the bombarding electrons suffer inelastic collisions, but unaccompanied by more radiation or more ionisation. It appears that 10·2 and 13·5 are atomic critical points, while 11·9, 12·6, 15·9, and 22·8 are molecular critical points, also that the radiation produced at 11·9 can be " handed on " throughout a volume of the gas and is therefore due to an excitation of a molecule without dissociation. Duffendack's observation is confirmed that the Balmer series lines appear at the 16-volts ionisation stage and shows, therefore, that here the dissociation of the molecule into atoms and the ionisation of one of these atoms occurs. A blue glow, of continuous spectrum extending from the yellow to the limit of the visible spectrum in the violet, was obtained at lower voltages than either the Balmer lines or those of the hydrogen secondary spectrum, and without any ionisation occurring. The experimental evidence suggests this continuous spectrum to be attributed to the formation of molecules (H_2 or possibly H_3) by the combination of neutral atoms produced by electronic-molecular encounters, which result in dissociation and atomic excitation. The results obtained are consistent with the view suggested by Pauli from theoretical considerations, that the ionisation of the hydrogen molecule by the process $H_2 \longrightarrow H_2^+ +$ electron requires about 23 volts energy, whereas by the process $H_2 \longrightarrow H + H^+ +$ electron it requires considerably less energy. Three forms of apparatus were employed in the experiments and are fully described, two being for the spectroscopic investigation and one for the accurate location of the critical electron energy values and of the origin of the various radiations.

H. H. Ho.

314. *Motion of Electrons in Hydrogen under Crossed Electric and Magnetic Fields.* **R. N. Chaudhuri.** (Phil. Mag. 46. pp. 553–564, Sept., 1923.)—In a previous paper [see Abstract 1203 (1923)] the current between kathode and anode was shown to be diminished by the application of a magnetic field at right angles to the electric field. For pressures up to 10 mm. the residual percentage of the initial current was found to be proportional to the pressure. The conclusion was drawn that the residual current was chiefly due to the collision of electrons with gas molecules, and the mean free path of the electrons deduced on this assumption agreed fairly well with that calculated from the kinetic theory. Hydrogen seemed to be an exception in both respects, and the present paper gives the results of a more detailed investigation for hydrogen. Using similar apparatus, it is found that the percentage residual current depends largely on the temperature of the hot filament [kathode], being greater when the temperature of the filament is lower. From the consistency with which the percentages are repeated after the filament has been strongly heated, it is concluded that the probable cause of the lower values when the filament temperature is higher is that in such cases more of the hydrogen is dissociated by the hot filament and the electrons are colliding with atomic as well as molecular hydrogen. The mean free path of the electrons being greater when the gas is in the atomic state, the residual current would naturally be smaller at higher temperatures. Curves are drawn for different temperatures showing the relation between percentage residual current and pressure. In every case the current is proportional to the pressure up to at least 2×10^{-2} mm. The mean free paths of an electron obtained by this method in molecular and atomic hydrogen are about one-third those calculated on the kinetic theory. This may be due to the formation of heavy ions and the carrying of some part of the residual current by these. G. A. S.

315. *Distribution of Velocities among Electrons Emitted by Hot Platinum in Hydrogen.* **H. H. Potter.** (Phil. Mag. 46. pp. 768–784, Nov., 1923.) —The first measurements on the energy distribution among the electrons emitted by hot metals were made by Richardson and Brown and by Richardson. Both the normal and the tangential components of the velocity were studied, and the experiments showed that the distribution of energy among the electrons emitted by platinum in air at low pressures was in close agreement with Maxwell's distribution law for a gas of a molecular weight equal to that of the electrons in thermal equilibrium at the temperature of the hot platinum. Some experiments were also made on lime-coated filaments and on platinum filaments in an atmosphere of hydrogen. In both cases the velocity distribution did not appear to be in agreement with Maxwell's law. The experiments on lime-coated filaments seemed to give fairly definite results, but in the case of hydrogen the results were too irregular to draw very definite conclusions from. The present series of experiments were undertaken in the hope of clearing up some of these points. The apparatus employed is described in detail with the help of diagrams. In the second part of the paper experiments on the velocity distribution are described, having first considered the theoretical aspect of the case. The electron emission from hot platinum is measured in vacuum and in an atmosphere of hydrogen. The presence of hydrogen at pressures of 1/20 mm. and over is found to affect greatly the measured average energy of the emitted electrons. Maxwell's distribution law is found to hold for the emission from pure platinum in a high vacuum. The linear relation between the logarithm of the current and the applied voltage is found to hold good in an atmosphere of hydrogen, but the average energy of the electrons has been found to be higher than that demanded by Maxwell's law. The average energy does not appear to be a regular function of the pressure. Experiments on the total emission indicate that if the platinum wire is quite clean hydrogen has little or no effect on the total emission at temperatures near 1450° C., but that the hydrogen has a considerable effect (usually increasing the emission) if the filament is contaminated. A. E. G.

316. *The Effect of Vapours upon the Mobility of Ions in Air.* **Maria Bělař.** (Akad. Wiss. Wien, Ber. 130. 2a. No. 7–8. pp. 373–381, 1921.) —Employing the flow method used by Becker [Abstract 383 (1908)], the author has determined the effect, if any, of certain vapours upon the mobility of ions in air. Benzyl alcohol and aniline produced no effect. Formaldehyde and propionaldehyde reduced the mobility of negative ions to a greater extent than that of positive ions. The reduction of mobility effected by ammonia was more marked in the case of positive ions. Results obtained with methyl alcohol, ethyl alcohol and ethyl acetate confirmed results previously obtained by Przibram in the case of these vapours [Abstract 1365 (1910)]. No definite difference in the effect produced was observed whether the air-vapour mixture was ionised, or the vapour added to air already ionised. The phenomenon is apparently closely connected with the power of association possessed by the respective vapours, and which is exhibited, for example, by their tendency towards polymerisation. J. S. G. T.

317. *Potential Measurements with Tesla Transformer. Correction.* **M. Wolfke.** (Phys. Zeits. 24. p. 303, July 15, 1923).—Certain formulæ referred to in Abstract 2256 (1923) are not correct, but the results given may be evaluated by means of a formula now given. A. W.

318. *Optical Constants of Certain Liquids for Short Electric Waves.* **J. D. Tear.** (Phys. Rev. 21. pp. 611–622, June, 1923.)—The great change in refractive index of a number of liquids in crossing the unexplored region separating the extreme infra-red from the shortest electric waves is of considerable interest. A notable example is the dispersion of water, the index of refraction changing from a value near 1·5 in the infra-red to approximately 9 for wave-lengths of a few centimetres. The study of the optical constants of these liquids has extended from wave-lengths of several metres to about 2 cm., but in much of the earlier work the method of waves on parallel wires was used. Lebedew and Lampa in their measurements of indices of refraction used prismatic cells of small angle. Later experimenters, following the lead of Cole, used the method of reflection, only Eckert and Möbius taking into consideration the absorption coefficients. The wide variations in the results of the various investigators may be accounted for in part by the errors introduced by diffraction when the reflecting and refracting surfaces used are but a few wave-lengths in extent and in part by the inherent difficulties in using a small Hertzian oscillator the emission of which tends to vary both in amount and in the degree of damping. The principal source of error lies in the determination of the wave-length of the radiation used. Optical constants are now measured for water, glycerin, methyl and ethyl alcohol for short electric waves of length 4 to 27 mm. Special Hertzian oscillators and radiometer receivers developed by Nichols and Tear [see Abstract 2257 (1923)] are used. For the extinction coefficient glass and ebonite cells were used; for the coefficient of reflection the liquid is held in a tilted rubber tray. The refraction indices are then computed by the Cauchy-Quincke formula. In a few cases the index is determined directly from measurements of the reflection from a thin layer of the liquid over a mercury surface as a function of the thickness since, due to interference, maxima occur at intervals of half a wave-length, providing the absorption is not too great or the reflection too small. Water shows absorption maxima at wave-lengths of 20, 7, and perhaps 2 mm., its index drops from 8·7 for 40 mm. to 5·3 for 4 mm. The experimental values agree with those computed by Rubens from the Debye theory for $\lambda > 40$ and $\lambda < 0{\cdot}2$ mm.; the discrepancies in the intermediate region are evidently due to the presence of two or three absorption bands, whereas only one is assumed. A. E. G.

319. *New Method of Determination of Period of High-Frequency Electric Oscillations. Determination of Velocity of Propagation of Electromagnetic*

Waves in Wire Conductors. **M. Mercier.** (Ann. de Physique, 19. pp. 248–287, May–June, and pp. 5–65, July–Aug., 1923.)—In the first part a new method of measuring absolute values of the period of electric oscillations of high frequency is described. It is claimed that this method enables a period of the order 1/100,000,000 sec. to be determined by direct comparison with a clock having a precision exceeding 1/100,000. The phenomena of harmonic and multiple synchronisation are investigated. The apparatus used is described in detail and illustrated by diagrams and photographs. In the second part, after a somewhat lengthy theoretical discussion, the experimental arrangements are described. The influence of external objects upon the precision of the measurements is dealt with, then the method of carrying out the experiments and details of a complete set of measurements are given [see also Abstract 1374 (1922)]. A. E. G.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

320. *Influence of Cold Rolling on the Electrical Properties of Sheet Steel.* (Report from Dept. of Communications, Tokyo [48 pp], Sept., 1922.) The samples consisted of silicon steel and ordinary steel. These were subjected to cold rolling and the electrical, magnetic, and mechanical properties were determined at each stage of rolling. The rate of increase of hysteresis loss is found to be nearly proportional to the reduction in thickness. The coercivity changes similarly, but the retentivity does not change appreciably. The magnetising force corresponding to different inductions increases gradually as the thickness is reduced. Change in the mechanical properties is always accompanied by a corresponding change in magnetic properties. The electrical resistivities and specific densities do not change appreciably. W. R. C.

321. *Effect of Tension on Change of Resistance and Thermoelectromotive Force by Transverse Magnetisation.* **A. W. Smith.** (Phys. Rev. 22. pp. 58–65, July, 1923.)—Electrolytic nickel in the form of wire, 1·4 mm. diameter, was placed between the poles of an electromagnet so that the field was perpendicular to the axis of the wire. The electrical resistance of the wire decreased when the field was excited, and the amount of decrease diminished when the wire was subjected to tensile stress. For a tensile stress of 21·2 kg./mm.^{2} the decrease was less than ¼ of the value when the wire is unstrained.

The thermoelectromotive force of the wire against copper was also measured. The effect of transverse magnetisation is to increase the electromotive force of the couple, but the increment is smaller when the nickel wire is under tensile strain. Observations of the Hall and Nernst effects on a Ni plate show that a tensile stress in the direction of the electrical or thermal current has no appreciable effect on the magnitude of these effects. The results obtained are discussed from the point of view of the electron theory, and the author is led to believe that changes of resistance, length, and thermoelectric force are to be attributed to atomic distortion under the action of the magnetic field or the tension, whereas the Hall and Nernst effects are due to the action of the magnetic field on quasi-free electrons. L. L.

322. *Effect of Torsion on Thermal and Electrical Conductivities of Metals.* **C. H. Lees and J. E. Calthrop.** (Phys. Soc., Proc. 35. pp. 225–

233; Disc., 233–234, Aug., 1923.)—The close connection which all forms of the electron theory disclose between the thermal and electrical conductivities makes it desirable that these quantities should be determined under as many different conditions as possible to see how far the theory is supported by the facts. Tension has been shown by various observers to produce changes of opposite sign in the two conductivities. [See Abstract 650 (1917).] The results of different observers for the effect of pressure are discordant among themselves.

In the present investigation wires with their ends held by water-cooled clamps, by means of which torsion can be applied, are heated centrally by a coil of wire bearing a current. Temperatures at two points on the main wire are taken by suitable platinum thermometers. The whole is surrounded by a water jacket at the temperature of the clamps, and a third platinum thermometer gives the temperature of this. Thus the heat conductivity is calculated. By passing a current through the main wire and measuring the fall of potential between two points with a potentiometer, changes in electrical conductivity on twist are measured. Wires of steel, aluminium, copper, and lead are tested and tables of results are given. The heat conductivity after twist does not return immediately to the value before twist. This is especially so with steel. Apart from this irregularity, twist decreases the heat conductivity of aluminium, copper, and lead by a few parts in 1000; in steel the decrease exceeds 1 per cent. The decrease appears to be independent of the direction of twist and proportional to the square of the angle of twist. The decrease in electrical conductivity is less in every case than the corresponding decrease in heat conductivity, but is also roughly proportional to the square of the angle of twist. G. A. S.

323. *The Passage of Electricity through Crystals.* **A. Joffé.** (Ann. d. Physik, 72. 6. pp. 461–500, 1923.)—The passage of electric currents through insulating crystals exhibits certain peculiarities which have not hitherto received explanation. Von Schweidler has opined these to be dielectric anomalies on the ground that after passage through a crystal the current decreases with time, and when removed the crystal is found to afford a reverse current. Work by Warburg and Curie is quoted. The present investigation, which has been partly carried out in association with W. C. Röntgen [see Abstract 1492 (1913)], shows that differences between previous results are due partly to admixture and partly to the previous treatment of the preparation used. A very convenient experimental installation is now described for such measurements. It is established that all the crystals investigated possess a specific resistance and that Ohm's law is experimentally valid when very short intervals of time are taken. Data for calcspar and quartz are included. The conductivity is found, moreover, to possess a very high temperature coefficient, *e.g.* at 100° C. it is $3 \cdot 10^4$ greater than at 0° C., and by choice of temperature it is possible to accelerate or retard conduction within the widest limits. The temperature influence is traced to two causes: (1) To a dissociation of the crystal components by temperature changes, *i.e.* a change in the number of such ions as are not bound in the crystal, but affected by external electric forces; (2) to a change in ionic mobilities. The problem of galvanic polarisation at high voltages is examined for calcspar and quartz, experiments being fully described, and a discussion of ionic equilibrium in quartz is given. Following this comes an investigation of the influence of radiation, which varies greatly with the type of crystal, Röntgen rays, α, β, and γ rays, and ultra-violet light being used. Pure crystals are finally examined, and the results compared with those of the natural substances. The last section is devoted to the electrolysis of crystals. H. H. Ho.

324. *On the Adiabatic and Isothermal Piezo-Electric Constants of Tourmaline.* **D. A. Keys.** (Phil. Mag. 46. pp. 999–1001, Nov., 1923.) —The question of any large difference in the piezo-electric constants of tourmaline, when compressed adiabatically and isothermally, is one of the greatest importance in making measurements by the piezo-electric method [see Abstract 587 (1922)]. In general, the crystal vessel is calibrated by applying static pressures to the crystals and finding the effect produced. This process is relatively slow as compared with the time taken for the pressure in an explosive wave to reach its maximum, so that the crystals are calibrated isothermally and used adiabatically; any difference in the piezo-electric constant in the two cases, therefore, causes an error in calibration. The experimental evaluation of this difference is so difficult to carry out, that the author deems it expedient to calculate it thermodynamically, as shown in the present paper. For tourmaline the difference between the adiabatic and isothermal piezo-electric constants is found to be about 0·33 per cent., so that only a very slight error is produced by isothermal calibration and adiabatic practice.
H. H. Ho.

325. *Contamination of Thermocouples.* **O. A. Hougen** and **B. L. Miller.** (Chem. and Met. Eng. 29. pp. 662–663, Oct. 5, 1923.)—It is well known that the thermoelectric power of thermocouples is affected by contact with silica protection tubes at high temperatures, and the authors have studied the magnitude of the effect for two types of couples: one platinum-platinum 10 per cent. rhodium and one base metal, chromel-alumel. The platinum couple was subjected to the following heat treatment:

Preliminary annealing-oxidising atmosphere.
50 hours at 900° C. in a reducing atmosphere.
50 hours at 1000° C. in a reducing atmosphere.
50 hours at 1200° C. in a reducing atmosphere.
Annealing at white heat-oxidising atmosphere.
50 hours at 1000° oxidising atmosphere.

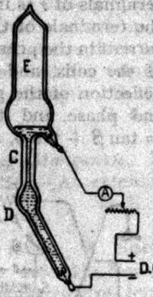
The chromel-alumel couple was subjected to the same heat-treatments, except for preliminary annealing and the 50-hour heating at 1200° C. The reducing atmosphere was obtained by loosely surrounding the silica tubes with graphite powder: the oxidising atmosphere by the natural circulation of air through the heated tube furnace.

Results of the Tests.—First 50-hour run, 900° C., reducing atmosphere; no change in the e.m.f. of either couple. *Second 50-hour run, 1000° C.*, reducing atmosphere; both couples showed a reduction in e.m.f. The thermoelectric power of the noble metal couple was reduced about ¾ per cent., of the base metal couple about 4 per cent. *Third 50-hour run, 1200° C.*, reducing atmosphere; the e.m.f. of the platinum couple showed a marked reduction. On annealing, the platinum couple recovered its e.m.f. to a marked degree and the base metal couple also showed a decided increase in e.m.f., but in this case there was a permanent alteration.

Oxidising treatment (1000° *C.*). The platinum couple showed no further alteration in e.m.f., the base metal showed an increase in e.m.f. Both couples had become brittle.

The general conclusion is that the siliconising of platinum can be almost completely removed, but that the siliconising of chromel-alumel couples produce some permanent alteration in composition which cannot be remedied by subsequent annealing. It seems that at high temperatures above 900° C. the silica tube becomes porous and permits penetration of the reduced silicon vapour. E. G.

326. *Mercury Lamp with Low Voltage and Low Wattage.* **E. L. Harrington.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 689–692, Sept., 1923.)—The lamp is constructed of pyrex glass with tungsten lead-in wires. It will only operate on direct current, and the lower lead must be negative. There are two types, one of which is shown in the figure. To start the lamp the circuit is completed through the unbroken column of mercury, and a small Bunsen flame is applied at the point D until the mercury boils. The first bubble of mercury clears the tube above D of mercury and furnishes the necessary vapour for carrying the discharge, at the same time creating the requisite "hot spot" on the kathode surface at D. The discharge is very concentrated and intrinsically brilliant. The current varies from 0·5 to 0·8 amp., whilst the drop in potential ranges from 20 to 30 volts. T. C. H.



327. *A Thermopile for Measuring Radiation.* **W. J. H. Moll.** (Phys. Soc., Proc. 35. pp. 257–260; Disc., 260, Aug., 1923.)—In this thermopile the junctions which receive the radiation are of low thermal capacity, while the inactive junctions are of large thermal capacity. This arrangement, while still remaining highly sensitive, ensures quickness of action and stability of zero. The couple elements are constantan and manganin in the form of foil 0·005 mm. thick. The inactive junctions are fixed to copper pins clamped in holes arranged along parallel lines on a brass plate. Lacquer electrically insulates the pins from the plate. The active junctions may be distributed areally or linearly. It is not necessary to screen the inactive junctions from the source of radiation. Used in conjunction with a suitable galvanometer, steady deflection is obtained within 2 secs. after admission of radiation. The use of a fluorite window is recommended to eliminate air currents. L. L.

328. *The Quadrant Electrometer.* **S. Jimbo.** (Ministry of Communications, Tokyo, Japan, pp. 1–27, Nov., 1922.)—The theory of the electrometer is discussed and a method of power-factor measurement is given. W. R. C.

329. *A Simple Compensation Method for Measuring the Capacity, and the Angle of Dielectric Loss, in Condensers and Cables.* **W. Geyger.** (Archiv f. Elektrot. 12. pp. 370–375, June 30, 1923.)—The arrangement is shown in Fig. 1, where C is the capacity to be measured, *r* is a non-inductive resistance, without capacity, in series with it, and connected to a source of alternating current. The primary S_1 of an air transformer is connected, in series with the inductance L and the resistance R, to the same terminals; and the secondary S_2 is connected, through a vibration galvanometer, with the terminals of r; the voltage P and the frequency ω are measured by suitable instruments. When there is no currect through the galvanometer, Fig. 2 shows the electrical relations. P is the resultant of the watt component P_w, which is in phase with the current I, and of the wattless component P_c, which is perpendicular to P_w and lags; α is the complement of the phase angle between P and I, and represents the total angle of loss in the capacity circuit; it is compounded from the angle of loss β, due to the ohmic resistance r, and the angle of dielectric loss δ, which is to be measured. The voltage p between the terminals of r is in phase with I and equal to rI, the voltage e between the terminals of the secondary of the transformer is $\eta\omega i$, where i is the current in the primary and η is a factor depending on the relative position of the coils, and can be obtained by suitable calibration. When the deflection of the galvanometer is zero, p and e are equal in magnitude and phase, and it is shown that $\tan\alpha = \omega L/R$, $\tan\beta = r \cdot \omega C$, $\tan\alpha = \tan\beta + \tan\delta$, and, since these angles are small in practice, $\alpha = \beta + \delta$

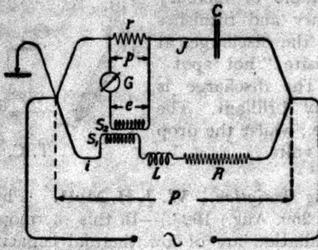


FIG. 1.

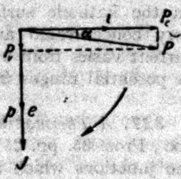


FIG. 2.

or $\delta = \alpha - \beta$. Since in the actual measurements $(\omega L)^2$ can be neglected as compared with R^2, and r^2 as compared with $1/(\omega C)^2$, it follows that $C = \eta/Rr$. The method has been tested out, and gives accurate results.

H. N. A.

330. *Use of the Audion for Absolute Measurement of very Weak Alternating Tensions in the Grid Circuits.* **Angelika Székely.** (Akad. Wiss. Wien, Ber. 131. 2a. No. 1. pp. 39–56, 1922.)—Various experimental arrangements are described and results obtained are given in both graphical and tabular form. It is concluded that the difficulties of standardising are so great that it is doubtful whether the methods described have any practical application.

A. E. G.

ALTERNATING CURRENTS AND MAGNETISM.

331. *Alternating Magnetism.* **W. M. Mordey.** (Engineering, 115. pp. 671–673, June 1, 1923. Paper read before the Royal Inst., May 18, 1923.)—A description of the effect of a.c. electromagnets on dust or filings of various materials. Particles of magnetite and cobalt are attracted, and form along the lines of force, but particles of specular hæmatite are repelled, and are therefore considered to be diamagnetic. When a two-phase current was applied to a row of electromagnets which acted on a mixture of gangue and hæmatite, a separation of the ores took place, the gangue remaining at rest and the hæmatite being repelled. A similar separating action was observed when tinstone and tungsten were mixed in water; the tungsten moved the more rapidly of the two. The a.c. magnets have no action on aluminium dust, and it is inferred that the effect observed is not due to eddy currents. Further, a solid metal disc placed half-way across one of the poles rotates in a direction opposite to that along which the loose particles are propelled. The particles also appear to rotate about some axis while moving bodily. Magnetic hysteresis is considered to play a part in the phenomenon, as cast iron showed great translational movement, whilst stalloy and nickel were but little propelled along the longitudinal axis, although these metal particles stood up in "fins" or thin ridges. As the frequency of the current alternations was raised, the vertical repulsion and fin stiffness increased, but the translational effect became weaker. With increased field strength the fins space themselves more widely. G. E. A.

332. *Magnetisation of Carbon Steels Containing Manganese.* **H. Pécheux.** (Rev. Gén. d'Él. 14. pp. 483–484, Oct. 6, 1923.)—An extension of the paper referred to in Abstract 2284 (1923). G. E. A.

333. *Null Method of Measuring the Gyro-Magnetic Ratio.* **W. Sucksmith** and **L. F. Bates.** (Roy. Soc., Proc. 104. pp. 499–511, Nov. 1, 1923.)—Richardson showed that if the magnetic properties of ferromagnetic substances are due to the rotation of the electron orbits of the atom, then a change M in the magnetic moment should be accompanied by a change U in the angular momentum, such that $U/M = 2m/e$, where m and e are the mass and charge of an electron respectively. Previous experiments show that the value of the ratio in practice is about half this. The present work is to check these results with increased accuracy and to determine the value of the ratio for Heusler alloys. A null method is used in which the oscillations set up in a vertically suspended cylindrical specimen by the alternating current in a co-axal helix are neutralised by making use of the current induced in a second small co-axal helix by the changes in magnetisation of the specimen. The frequency of the alternating current is the same as the natural frequency of the suspended system. The means employed to eliminate many possible disturbing factors are described in detail. As no measurement of magnetic moment, frequency, or damping is involved, a considerable gain in precision is obtained. The method is independent of time lag in magnetisation, and so can be applied to Heusler alloys. Tables give the values obtained for $\frac{U}{M} \cdot \frac{e}{2m}$, *viz.* $(0{\cdot}503 \pm 0{\cdot}006)$ for iron, $(0{\cdot}501 \pm 0{\cdot}002)$ for nickel, and $(0{\cdot}501 \pm 0{\cdot}003)$ for Heusler alloy, *i.e.* 0·5 for all within the limits of experimental error. G. A. S.

334. *The Invention of the Compass.* **L. de Saussure.** (Arch. des Sciences, 5. pp. 149–181, May–June, and pp. 259–291, July–Aug., 1923.)

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

335. *Glow of Phosphorus, and its Extinction by Moist Oxygen.* **(Lord) Rayleigh.** (Roy. Soc., Proc. 104. pp. 322–332, Oct. 1, 1923.)—Describes experiments on the effect of passing a blast of air, with more or less oxygen, over a slab of phosphorus under various conditions as regards temperature, amount of moisture present, etc. Some of the more important results are as follows: The velocity of blast necessary to blow away the glow of phosphorus increases enormously with rise of temperature. On the other hand, it is enormously diminished by enriching the air blast with oxygen. The velocity of the blast measures the rate of propagation upstream of the glow through a mixture of phosphorus vapour and oxygen. When the velocity of propagation is reduced, either by cooling or by adding oxygen, to less than 1 cm. per sec., the condition of extinction is approached. From this point of view the known extinction by an atmosphere of moist oxygen alone is seen to be the limiting case of slow propagation. It follows that extinction is due to the failure of the process which causes propagation. This was shown in a previous paper [Abstract 1990 (1921)] to be in all probability a catalytic action of the products of combustion. Excess of oxygen, like other inhibiting substances, " poisons " these products, or makes them unfit to act, perhaps by a process of condensation similar to that which is found to clog the motion of the ions in gaseous combustion. A. W.

336. *The Surface Energy of Crystals and their Form.* **M. Yamada.** (Phys. Zeits. 24. pp. 364–372, Sept. 1, 1923.)—The relation between the surface energy of crystals of the alkali halogen compounds has been investigated by Born and Stern, who found that, as a result of thermodynamical laws, a crystal in a state of equilibrium has a form which corresponds to a minimum surface energy; if σ is the energy per unit of surface, and F is the area of the surface, $\Sigma\sigma F$ is a minimum [see Abstract 499 (1920)]. Wulff draws from a certain point straight lines in all possible directions, and cuts off from each line a length proportional to the σ of the surface at right angles to the line; the innermost polyhedron bounded by the perpendicular planes through these points represents the crystal form. The author proceeds along these lines, and calculates the surface energy for any surface, in a rock-salt crystal, by considering it as made up of a series of steps, the tread of the step being in the (1, 0, 0) plane and the rise at right angles to this; he adds together the energy required to separate the treads and that required to separate the rises, which are in each case equal to the distance $\delta/2$ between two neighbouring (1, 0, 0) atomic layers; and making use of Madelung's value of the mutual electrostatic energy between a row of ions of alternate signs and an isolated ion, obtains an expression for the surface energy of any plane in the crystal. The method is also applied to other lattice forms. It is shown that the polyhedron crystal forms, and the fact that only surfaces with simple indices occur (law of rationality), are direct results of the smallness of the atomic sphere of action. The possibility of the existence of curved crystal surfaces, as in some natural diamonds, is mentioned, and the cleavage of crystals is explained. H. N. A.

337. *The Electronic Theory of Valency. Part II. Intramolecular Ionisation in Organic Compounds.* **T. M. Lowry.** (Faraday Soc., Trans. 19. pp. 488–496, Nov., 1923. Phil. Mag. 46. pp. 964–976, Nov., 1923.)—Inorganic compounds are treated in Part I [Abstract 1675 (1923)]. The formula for ethylene may be written $H\,{:}\,\overset{\overset{H}{\cdot\cdot}}{C}\,{:}\,\underset{\cdot\cdot}{\overset{\overset{H}{\cdot\cdot}}{C}}\,{:}\,H$, where the C on the left has the resultant charge $+e$ or $+1$ and that on the right -1; the bond is a "mixed double" one and the formula may be conventionised as $\overset{+}{C}H_2\text{—}\overset{-}{C}H_2$ or $CH_2 \underline{\longrightarrow} CH_2$; acetylene $H\,{:}\,C\,{::}\,\overset{\cdot\cdot}{C}\,{:}\,H$ contains a "mixed triple bond; the left carbon has charge $+1$ and the right -1; the conventional formula will be $\overset{+}{C}H{=}\overset{-}{C}H$ or $CH \underline{\underline{\longrightarrow}} CH$. A large number of organic compounds have been formulated in a recent paper (Chem. Soc., J. 123. p. 822, 1923); a single symbolism may now be employed to express most of the various classes of bonds, such as centric bonds in aromatic compounds, carbonicum bonds, mobile hydrogen atoms, residual affinities, partial valencies, principal and subsidiary valencies, etc. It is suggested as possible that the diamond bond, with 1·5 Å. between the centres of adjacent carbon atoms, and the electrovalent link, with its radiating fields of electrostatic force, may perhaps be sufficient to express the facts of chemical combination. This extension of the theory of intramolecular ionisation brings the reactivity of organic compounds into line with that of inorganic ions, and makes it possible to regard all chemical action as ultimately ionic in character. The resting forms of the molecules need not be identical with their ionised or reactive forms; some organic compounds, however, probably have a permanently ionised structure, comparable with that of metallic salts; in other cases evidence is quoted to show that this condition results from a definite process of activation. Attention is directed to several phenomena which receive a simple explanation in the "crossed polarities" of compounds which have hitherto been classed as "conjugated." The properties of "multipolar ions" are referred to as furnishing a basis for a novel theory of tautomeric ions, and an explanation of their readiness to yield coordination compounds. H. N. A.

338. *The Electronic Theory of Valency. Part III. The Transmission of Chemical Affinity by Single Bonds.* **T. M. Lowry.** (Faraday Soc., Trans. 19. pp. 496–502, Nov., 1923. Phil Mag. 46. pp. 1013–1020, Nov., 1923.)—In a chain of atoms one atom may exert an effect on its neighbours, which is always of the same kind, or alternate atoms may be affected in opposite ways (Lapworth's principle of alternate induced polarities). [See preceding Abstract and Abstract 1675 (1923).] In the opinion of the author the existence of phenomena which cannot be explained in one of these two ways is still unproved. A number of organic compounds are considered, and it is concluded that the reactivity of the methyl-group in ethyl-crotonate is in harmony with the theory of polar double bonds; it cannot be used as a proof of the existence of polarised single bonds (polar covalencies), since it receives a simple interpretation in terms of Thiele's theory of conjugation. The small fluctuations, which are observed in the strength of unsaturated acids, as the double bond is moved along the chain, may be attributed to steric influences, such as those which Pickard has discovered in optically active compounds. The fact that amino acids are sometimes stronger than the acids from which they are derived is attributed to the acylous (negative) character of the amino group; this is usually masked by the direct neutralising action of the basic group. The conclusion is drawn that alternate polarities are characteristic of conjugated systems, and that it is not yet proved that they can be developed in chains of single bonds, where both acylous and basylous (positive) groups produce effects of constant sign. H. N. A.

339. *Aqueous Solutions.* **A. Kling** and **A. Lassieur.** (Comptes Rendus, 177. pp. 109–111, July 9, 1923.)—The appearance of a note in French by Armstrong (Comptes Rendus, 176. p. 1892, June 25, 1923) has stimulated the authors to present a summary of their views on solutions as set out in the "Revue annuelle de Chimie analytique," published in "Chimie et Industrie" of May 20, 1923. They adopt the familiar view that water is a mixture of hydrol H_2O and its polymers, but assume that hydrol can exist in two forms, $H_2{=}O$ which is supposed to be basic, and H—OH, which is supposed to be acid, whilst the polymer H_4O_2 formed by uniting these is supposed to be neutral. The quantity that is commonly called "hydrogen ion concentration" these authors regard as the concentration of H—OH, whilst "hydroxyl ion concentration" is the concentration of $H_2{=}O$. T. M. L.

340. *Aqueous Solutions. Origin of Osmotic Effects.* **C. Gillet.** (Comptes Rendus, 177. pp. 257–258, July 23, 1923.)—In response to a recent note of Armstrong (Comptes Rendus, 176. p. 1892, June 25, 1923), the author recapitulates the views that he has advocated since 1908 (Bull. Soc. Chim. Belg. 23. p. 119, 1909; 26. p. 145, 1912; Revue générale des Matières colorantes, Dec. 1921 to June 1922). He also suggests that hydrol can act in an acid or basic form. An aqueous solution is regarded as a liquid compound resulting from the interaction of hydrol with other molecules—this compound being stable only when its dissociation-constant is less than that of dihydrol. Solutions of equal osmotic pressure contain equal numbers of molecules of gaseous hydrol, which obeys the laws of gases even when in solution. The author has applied these ideas to electrolytes and electrolysis, and also to the explanation of phenomena observed in colloidal solutions. T. M. L.

341. *Corrosion Tests on Certain Nickel Alloys.* **F. Orme.** (Faraday Soc., Trans. 19. pp. 199–200, July, 1923.)—The results are given of tests on the action of dilute solutions of various acids in the cold for 14 days on: (1) A so-called "stainless" nickel alloy containing 64 % Cu, 35 % Ni, and 1 % Sn; (2) a "non-corrodible" nickel alloy, composed of 60 % Cu and 40 % Ni; and (3) the "seconds" quality nickel-silver standard for spoon and fork manufacture, containing 14 % Ni, 30 % Zn, and 56 % Cu. In each of the alloys the amounts of corrosion occurring in the different acids used are approximately in the same order. The results indicate the inaccuracy of the terms stainless and incorrodible, applied to alloys (1) and (2). As regards tartaric acid solution, the ordinary standard nickel-silver is actually superior to these alloys in its resistance to corrosion. In acetic acid solution, the losses are almost identical for the three alloys, and even with hydrochloric and sulphuric acid solutions the inferiority of ordinary nickel-silver to the other two alloys is not pronounced. Examination of the surface appearances of the metals after immersion in the acid solutions gives little noteworthy information, except perhaps in the case of acetic acid; here the alloys (1) and (2) appear to have retained their original surface lustre to a distinctly greater degree than the nickel-silver. T. H. P.

342. *Mechanism of the So-Called "Dry Corrosion" of Metals.* **U. R. Evans.** (Faraday Soc., Trans. 19. pp. 201–212; Disc., 213–230, July, 1923.)—Experiments on the behaviour of apparently dry metals, roughened with emery, show that no corrosion occurs when they are kept over sulphuric acid and only slow superficial corrosion when they are kept over water. The rate of attack is greatly increased by the presence of volatile electrolytes in the air, sulphur dioxide being most dangerous to iron and nickel, ammonia to copper and its alloys, and hydrogen chloride to zinc and aluminium; hydrogen sulphide and carbon dioxide somewhat increase the rate of rusting of iron, but produce only superficial changes on other metals. Contrary to common belief, the corrosion of iron is not caused by the presence of ammonia. Corrosion of metals by volatile electrolytes appears to require the presence of some moisture, but proceeds in air which is distinctly unsaturated. Special phenomena occur at the contact of dissimilar metals, apparent electrochemical protection being observed in certain cases. The phenomena are explained best if it is considered that electrochemical action occurs in the adherent (usually invisible) film of moisture. Volatile electrolytes increase the electrical conductivity of the film, and thus accelerate corrosion, and where they tend to produce hygroscopic corrosion products they induce absorption of further moisture and thus increase the thickness of the film. In such cases as zinc in hydrogen chloride, copper in ammonia, and nickel in sulphur dioxide, the metal, originally dry, soon begins to shed liquid copiously, corrosion then becoming very serious. T. H. P.

343. *Elasticity of Organo-Gels of Cellulose Acetate.* **E. W. J. Mardles.** (Faraday Soc., Trans. 19. pp. 118–133; Disc., 134, July, 1923).—The determination of the elasticity of a gel is complicated by the persistence of deformation and optical anisotropy after removal of the stress, the elasticity being perfect only for very small stresses applied for a short time. The phenomenon of the strain, variable with time and partly reversible, and also the persistence of deformation and optical anisotropy have been attributed to the formation of a metastable phase owing to the altered orientation of the molecules composing the complexes which have aggregated to form the gel structure.

The relationship between the modulus of elasticity and concentration for the organo-gels of cellulose acetate corresponds with no simple formula. Over limited ranges at the higher concentrations the expression $E = kC^n$ is obeyed approximately, the value of n decreasing with fall of temperature. The curve connecting log E and the temperature is approximately rectilinear over the range of temperature employed. The possible physical significance of these relations is discussed. For similar temperatures there is a close connection between the elasticity of a gel and the rate of its formation, both being functions of the number of particles which aggregate to form the gel structure. Addition of substances to the gel affects the modulus mainly in proportion to the change in the number of particles which aggregate. The changes with time in the modulus of rigidity of the gels associated with the reversible sol to gel transition have been studied and the significance of the shape of the curves correcting elasticity and time is discussed. During gelation and solation there appears to be a marked hysteresis effect; in general, at any particular temperature the elasticity of a gel is lower with a fallen temperature than when the temperature has risen. T. H. P.

344. *Liesegang Rings. III. Effect of Light and Hydrogen Ion Concentration on the Formation of Colloidal Gold in Silicic Acid Gel. Rhythmic Bands of Purple of Cassius.* **E. C. H. Davies.** (Am. Chem. Soc., J. 45. pp. 2261–2268, Oct., 1923.)—Silicic acid gel was prepared by slowly adding 500 c.c. of water glass ($d = 1 \cdot 16$) to a mixture of 500 c.c. of 2·975 N sulphuric acid and 40 c.c. of 1 % gold chloride solution. The mixture was filtered before use. The gel was allowed to set in test tubes and 5 c.c. of saturated oxalic acid was then added to each tube. No bands were found in tubes protected by black paper, but the formation of the rings was remarkably affected by light of short wave-length. It was also shown that there is a distinct relation between the hydrogen ion concentration and the size of "pockets" in which the gold is formed. The purple of Cassius was obtained in true Liesegang bands. [See Abstract 582 (1923).] F. J. B.

345. *The Law of Distribution of Particles in Colloidal Suspensions, with Special Reference to Perrin's Investigations. Part II.* **A. W. Porter** and **J. J. Hedges.** (Faraday Soc., Trans. 19. pp. 1–3; Disc., 3–5, July, 1923.)—A comparison is made of the results given by a formula deduced to evaluate the distribution of particles in a colloidal suspension [Abstract 392 (1923)] with measurements made in earlier work by Costantin [Abstracts 1634 and 2033 (1914)]. Further measurements are made with an emulsion of paraffin in water as representing a case where the particles are specifically lighter than the medium. The radius of particles of a specially prepared medium was ascertained by measurement to be 2×10^{-4} cm. The emulsion was examined in regard to its distribution with height. As was expected, the change of concentration occurs only at the bottom of the containing vessel. There is an increase of concentration with height near the base. The experimental determinations of the numerical concentrations at different depths agree with a formula of the type previously derived. J. N. P.

346. *Specific Inductive Capacity of Colloidal Solutions.* **J. Errera.** (J. de Physique et le Radium, 4. pp. 225–239, July, 1923.)—Further study [see Abstract 549 (1923)] is made of the relation between the specific inductive capacities of colloidal solutions and of the respective solvents. Solutions of the type exemplified by a sol of As_2S_3 and a sulphide of silver, hydrosols of silver prepared by pulverisation in the arc according to Bredig's method, and by a freshly prepared sol of ferric hydroxide, have the same specific inductive capacity as the pure solvent. The sols of vanadic anhydride are exceptional. A sol containing 3 parts per 1000 has a specific inductive capacity of 1280, which value, although not a maximum, is about 15 times as high as any other known liquids. The specific inductive capacity of such sols is not constant, nor is it independent of the intensity and frequency (when there is no dispersion) of the current applied for its measurement. The increase of specific inductive capacity (as with the optical anisotropy) is brought about by the prismatic form of the V_2O_5 particles, which, however, must be oriented and free from heterogeneous brownian movement. A. B. C. L.

347. *Hardness.* **C. A. Edwards** and **C. R. Austin.** (Iron and Steel Inst., J. 107. pp. 323–340; Disc., 341–342, 1923.)—Experiments were made, by means of a modified form of the Shore scleroscope, on the hardness of aluminium, tin, copper, brass, cupro-nickel, nickel, mild steel, annealed tungsten steel, chrome-nickel steel, quenched carbon steel, and air-cooled tungsten steel. The work involved a determination of:

(1) Heights of fall and heights of rebound.

(2) Heights of fall and volumes of indents produced.

(3) The Brinell hardness numbers and the rebounds obtained from falls that gave a certain constant volume of indent.

(4) The Brinell hardness numbers and rebounds obtained from a constant height of fall.

It was found that the relationship between the heights of fall and heights of rebound showed a considerable deviation from a straight line for all the materials tested, except air-cooled tungsten steel which gave rebounds nearly proportional to the fall. The curves of the relationship between the height of fall and volume of indent produced show that the amount of deformation expressed in terms of the volume of indent is a linear function of the energy absorbed. The Brinell numbers for the range of metals tested vary as the square root of the rebound obtained when a constant amount of deformation is produced. Rebounds were found to be very much the same when falls of 25 cm. are used and when the Brinell value is greater than 300. The dynamic method therefore fails to discriminate between metals which are more than moderately hard. F. J. B.

348. *Change of Density of Iron due to Overstrain.* **J. W. Landon.** (Iron and Steel Inst., J. 107. pp. 455–461; Corres., 462–463, 1923.)—Rods of iron containing carbon 0·058 %, sulphur 0·036 %, phosphorus 0·185 %, manganese 0·255 %, and a trace of silicon, were turned down from ¾ in. diameter to ⅝ in. diameter for a length of 9½ inches. They were then twisted in a torsion machine and specimens 2 in. long were cut from the rods and the densities determined. It was found that the overstrained iron had a lower density than the unstrained metal, and that the lowering was greater the greater the angle of twist:

Angle of Twist....	0	70·5	150	225	262
Density at 0°	7·7149	7·6678	7·6136	7·5802	7·5757

The results indicate that the maximum decrease of density due to overstrain for the material used is nearly 2 %. F. J. B.

349. *Some Experiments on the Hardness and Spontaneous Annealing of Lead.* **A. L. Norbury.** (Faraday Soc., Trans. 19. pp. 140–148; Disc., 148–151, July, 1923.)—The time factor is an important variable in Brinell tests on lead, differences of the order of seconds having appreciable effects upon the dimensions of the impressions. The author describes an adaptation used for making low-load Brinell impressions with a lever tensile testing machine of the Buckton 10-ton type, in which the load could be applied and removed instantaneously. A screw jack was employed to raise and to lower the beam very rapidly in this case. The paper in question, in addition to containing a description of this adaptation, includes a section on Brinell hardness tests on lead using different loads maintained for various lengths of time, the results being interpreted according to Meyer's formula $L = ad^n$, where L = load applied (in kg.), d = diameter of impression produced (in mm.) and a and n are two constants which depend upon the material under test. It is shown that the values of n for the shorter times of loading (*viz.* $n = 2{\cdot}28$ to $2{\cdot}33$) are similar to those obtained with annealed iron or copper. Meyer in his original paper gives $n = 1{\cdot}91$, and the author explains this low value as being due to the "time factor."

A third section of the present paper considers the effect upon the hardness of cold hammering, and indicates that (1) lead is hardened by cold work, and within certain limits the greater the amount of cold work the greater the hardening; (2) lead is spontaneously annealed at room temperature (16° to 18° C.); and (3) the rate of annealing increases with the amount of deformation. This introduces the interesting result that lead which has been severely hammered shows no increase in hardness. In this case the severe deformation has caused such a rapid annealing that the lead is dead soft in about 20 seconds after hammering. Reference is made to the work of T. Kirke-Rose, who demonstrated the fact that lead is hardened by cold-rolling and that it anneals itself spontaneously at 10° and 13° C. Certain controversial results are also mentioned. In the *discussion*, **A. S. E. Akermann** mentions the fact that considerable agreement appeared to exist between the laws for clay and those for metals. He referred to the method of testing by dropping a loaded ball on to the surface of the metal to be tested, employed by C. A. Edwards and others, which led to the relation $d = CE^{\frac{1}{4}}$, where d = diam. of the indentation (in mm.), C = a constant, and E = energy of the blow in lb.-ins. For clay the speaker found the relation to be $d = CE^{\frac{1}{3}}$, the units being metrical in this case. A. W. J.

350. *Heat and Acid-Resisting Alloys* (*Ni–Cr–Fe*). **J. F. Kayser.** (Faraday Soc., Trans. 19. pp. 184–195, July, 1923.)—All the nickel-chromium alloys in commercial use contain between 10 and 50 per cent. of chromium, greater proportions of the latter increasing the viscosity to such an extent as to make casting almost impossible. For furnace parts, case-hardening boxes, etc., 25–35 per cent. Cr is common, and for resistance wire 10–15 per cent. The hardness increases with the proportion of chromium, but before it reaches a value suitable for cutting tools the brittleness becomes excessive. To reduce cost the chromium is now introduced as ferro-chromium, the properties of the alloys being then indicated roughly by zones on an equilateral triangle showing the percentages of nickel, chromium and iron. All the alloys containing not less than 10 per cent. Cr, together with not more than 28–30 per cent. Fe are equally resistant towards oxidation, and the permissible proportion of iron depends on the magnitude of the stress to be withstood. Other elements also are frequently present in considerable amounts, these including carbon, silicon, aluminium, manganese, and copper. For material to be drawn into wire or forged, a low carbon-content, say below 0·3 per cent., is necessary; the softness and ductility increase as the proportion of carbon diminishes. Two per cent. of silicon affects

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the physical properties of nickel-chromium alloys but little, but 5 per cent. produces intense brittleness and hardness and lowers the resistance towards sulphur dioxide.

Nickel and aluminium form an intermetallic compound NiAl characterised by a high heat of formation and a melting-point above 1700°, which is about 300° above that of either constituent. Aluminium has a remarkable hardening influence on nickel and on nickel-chromium alloys. Some of the commercial alloys contain copper in considerable proportions, but this is of no advantage. Compositions of a number of the commercial alloys are given, and the physical properties discussed.

The corrodibility of the alloys considered varies with the composition, but if the silicon does not exceed 2 per cent., and the combined carbon, silicon, and manganese 4 per cent., the properties of these resistant alloys are closely similar. Such alloys resist perfectly the corrosive action of the atmosphere in presence of either hard or soft or sea water, no heat-treatment or surface-polishing being necessary. Stainless steel, on the other hand, must be correctly heat-treated and free from surface scale or pit marks, such defects always leading to corrosion. A table is given showing the effect of a few common chemical reagents on these alloys and on stainless steel. The alloys are readily soluble in aqua regia or hydrochloric or sulphuric acid, but are not soluble in nitric acid. The most remarkable property of these alloys is their resistance, at any temperature below their melting-points, towards the scaling action of furnace gases of either a reducing or an oxidising nature. The introduction into the gases of either hydrogen sulphide or sulphur dioxide is, however, fatal to even the best nickel-chromium alloy, a scale with very high sulphur content being then formed. T. H. P.

351. *Resistance to Corrosion of Stainless Steel and Iron.* **J. H. G. Monypenny.** (Faraday Soc., Trans. 19. pp. 169–183, July, 1923.)—An account is given of the effect of variations in the composition and heat treatment on the resistance to corrosion of stainless steel. There is little doubt that heterogeneity in a metal tends to increase corrosion owing to galvanic effects, this being particularly evident in the case of steels; the carbide present is electronegative to the iron and, other things being equal, steel will corrode faster than pure iron. With any given steel, the greatest resistance to corrosion is obtained after quenching so as to give a homogeneous martensite, the least resistant form being obtained when the steel is annealed in such a manner as to produce complete separation of carbide and ferrite. The separation of carbide not only tends to decrease the resistance to corrosion owing to galvanic phenomena, but, as the separating carbide contains much chromium, it lowers the concentration of the chromium in solution in the iron and thus increases the solubility. The greatest resistance will be obtained by quenching from a temperature sufficiently high to dissolve all the carbide in the steel. In practice, however, it is found that a temperature of 900–950° gives, with normal steel, a ground mass practically insoluble in water and certain other media, and that higher temperatures produce no marked improvement but involve increased risk of cracking during hardening. The sudden and pronounced fall in hardness occurring on tempering between 500° and 600° is accompanied by lessened resistance to corrosion, and the material may stain, although only slowly, with vinegar.

As regards annealing, if steel be cooled slowly from a temperature sufficiently high to give complete homogeneity, the structure will consist of pearlite, either alone or with ferrite or free carbide depending on the carbon content. If, however, the annealing temperature is within the range giving some free, undissolved carbide, the resulting structure is granular; in this condition it is much softer and somewhat less resistant to corrosion than when hardened and fully tempered. In the latter state, a normal stainless steel is usually quite unattacked by the alcoholic picric acid used for etching, whereas the same steel may be slowly etched when annealed. When severely distorted, stainless steel rusts comparatively readily; thus, the polished material is more resistant than a roughly machined surface, owing to the absence in the former case of the distorted skin produced by the machining.

As regards the composition, resistance to corrosion is increased by diminishing the carbon content and by increasing the chromium content. Owing to considerations of cost, the percentage of chromium is usually 11–14, and such steels with less than about 0·4 per cent. of carbon are stainless to vinegar when suitably hardened. The presence of about 1 per cent. of silicon or 2 per cent. of nickel has little effect on the corrodibility. Nickel, however, lowers appreciably the critical ranges of the steel and markedly augments the capacity for air hardening, much larger proportions of nickel render the steels austenitic and far more highly resistant to attack by mineral acids. The scale produced by heating stainless steel to high temperature would cause local corrosion and must, therefore, be removed by machining or suitable pickling, sandblasting being apparently ineffective. Hardened and tempered stainless steel is unaffected by tap water, sea water, river water, well water, or ammonia, alkalis, or alkaline carbonates in all concentrations; aqueous salt solutions have little or no effect. Commercial vinegars (unless adulterated with mineral acid) and fruit juices do not attack stainless steel, although pure acetic and citric acid solutions of corresponding strength, owing to the absence of the protecting emulsoids, exert a distinct corrosive action. Hydrochloric, sulphuric, and sulphurous acids attack these steels rapidly; very dilute nitric acid acts slowly, but the concentrated acid practically not at all. Corrosion by atmospheric agencies or by superheated steam is very slow, and lubricating oils, greases, benzol, paraffin, petrol, etc., appear to be without action. Stainless steel resists scaling at temperatures up to about 825°, but at higher temperatures it scales with increasing rapidity. T. H. P.

352. *Constitution of Iron Carbon Silicon Alloys.* **K. Honda** and **T. Murakami.** (Iron and Steel Inst., J. 107. pp. 545–583, 1923.)—A study of the constitution of alloys of iron containing up to 5 % C and 25 % Si. One hundred and twenty alloys in this region of the ternary triangle were made up and submitted to thermal, magnetic, and dilatometric analysis, and in addition a microscopic examination was made of alloys after different heat-treatments. *Results.*—Two carbides exist in the system, cementite, which only occurs if the silicon content is less than 5·5 %, and a double carbide probably consisting of cementite and iron silicide. This carbide is non-magnetic and easily decomposes to form graphite. The solubilities of both carbides decrease with increase of silicon. The A_1 and A_3 points are raised, but their magnitudes decreased with increase of silicon. The A_2 point, on the other hand, is lowered and, above a certain silicon content, occurs below the A_1 point. J. L. H.

353. *Potential Energy of Cold-Worked Steel.* **T. F. Russell.** (Iron and Steel Inst., J. 107. pp. 497–511; Corres., 512–515, 1923.)—The paper is largely theoretical and does not lend itself to abstract form.

F. J. B.

354. *Invar and Related Nickel Steels.* (Bureau of Standards, Circ. No. 58. [93 pp.], Washington, 1923.)—This circular is mainly a compilation of data obtained during the last 30 years by various investigators, on the different properties of nickel steels. Particular attention is given to "invar." The results of investigations made on the various physical properties of nickel steels or pure nickel-iron alloys are presented largely in diagrammatic and tabular form.

The nature of the anomalies in behaviour met with in these steels and characterised by their irreversible and reversible phenomena is discussed in the light of the results obtained on their various physical properties. In particular, the anomalous behaviour in the thermal expansivity of different nickel-iron alloys at various temperatures is illustrated by a number of diagrams, and the rule of corresponding states formulated by Guillaume has been applied in interpreting some of the results. The theories advanced as an explanation for this anomalous behaviour are dealt with briefly. The anomalies in the elastic modulus of nickel steels, of practical importance in the horological industry, and also the constancy in dimensions of invar are discussed. Attention is directed to "Elinvar," a recently introduced nickel steel containing 37 per cent. nickel and 12 per cent. chromium, or its equivalent, and possessing an invariable modulus of elasticity over a large temperature range as well as a low thermal expansivity. The circular is well illustrated with microphotographs of selected nickel steels, and graphs showing the different physical properties of the nickel steels. The mechanical properties of iron-nickel alloys are also dealt with, and reference is made to the work of Hadfield, Dumas, Guillaume, Guillet, Giessen, St. Etienne, and others. A special section describes the application of these nickel steels and alloys. The sources of supply for various nickel steels, more particularly in America and Switzerland are enumerated, and a useful "selected" bibliography upon the subject is given at the end. The whole paper represents a fairly complete survey of the subject in question.

A. W. J.

355. *The Production of Single Metallic Crystals and some of their Properties.* **H. C. H. Carpenter.** (Iron and Steel Inst., J. 107. pp. 175–202; Disc., 203–211, 1923. Engineer, 135. pp. 551–552, May 25, 1923. Abstract.) —This paper contains an account of investigations made by the author and Miss Elam in connection with single metallic crystal production. It was shown about 2 years ago that very large single crystals of aluminium could be regularly produced by special methods, and most of the results given refer to this metal, although a brief reference is given to mild steel, silver, and copper crystal production. The principles of crystal growth which have been established are enumerated, and their bearing upon the present results are discussed. The production of single crystals in aluminium sheet, in the form of a test-piece $4 \times 1 \times 0{\cdot}125$ in., is described.

After machining and subsequent heating there were about 150 crystals to the linear inch. By two thermal and one mechanical treatments the parallel portion of the test-piece was converted into a single crystal. Particulars are given of the temperature and time of heating before stressing, in this process, together with those relating to the stress and elongation caused. For the " 150 to the inch " crystal condition tensile tests on specimens gave an ultimate stress of 4·5 to 4·7 tons. sq. in., with 36 to 38 per cent. extension on 3 in. The values obtained in tests upon single crystal specimens varied from 2·80 to 4·08 tons sq. in., the extension varying from 34 to 86 per cent. on 3 in. Five types of mechanical stretching and fracture were noted. Photographic reproductions are included of the crystallised test-pieces, one set of 10, showing the diminishing size of crystals with increase of strain, in the production treatment. Various types of fracture of single crystal test-pieces, in the parallel portions are also illustrated. The results of stress tests of test-pieces consisting of two crystals, are described and illustrated, and it is shown that each test-piece behaves according to one of the five types previously mentioned, provided that the whole test-piece at the point of fracture consists of a single crystal. The production of single crystals in round bars of aluminium of 1 inch diameter, subsequently machined to diameters of 0·564 and 0·798 was also successfully accomplished; some interesting tensile test results are described in the case of these bars. The questions as to why abnormally large crystals form on heating after a small deformation, and gradually decrease in size as deformation increases, and why after a particular degree of deformation it is possible to form a single crystal from an aggregate of several millions, are dealt with from the theoretical and experimental viewpoints, reference being made to X-ray analyses. A. W. J.

356. *The Lattice Structure, Directions of Sliding, and Sliding Planes of White Tin.* **H. Mark** and **M. Polányi.** (Zeits. f. Physik, 18. 2. pp. 75–96, 1923.)—The authors have previously studied the stretching of single crystal wires of zinc [Abstract 991 (1923)]; and in the present paper have extended the investigation to similar wires of tin. E. v. Gomperz has shown that single crystal wires can be obtained direct by drawing out of the melt [Abstract 1030 (1922)]; and O. Haase showed that the temperature of the pure melted tin should be kept between 240° and 250°, and the velocity between 0·1 and 0·05 cm. per sec.; the formation of ductile wires is facilitated by using a ductile crystal to draw them out of the melt. The general type of phenomena, when such tin crystals are stretched, is very similar to that obtained with zinc crystal wires. Wires of approximately cylindrical section stretch into a flat band, which shows typical sliding ellipsis, as in the case of zinc; some very interesting photographs are included in the paper, which show that the ellipses are not quite as regular as those of zinc; in some cases the bending round of the sliding surfaces into the direction of the stretching force can be seen. The lattice of tin was determined from the rotation diagrams, by means of the layer line relations; $a = 5{\cdot}84$ Å.; $c = 3{\cdot}15$ Å.; the elementary body is space centred, and contains 4 atoms; a figure shows their relations to one another; the crystals are ditetragonal-bipyramidal, space group D_{4h}^{19}; the sliding directions observed are [100], [101], and [111] (only when warm); [100] is the most frequent; this is the direction in which the zinc atoms are closest together; on the other hand the [111] direction, which comes next in this respect (4·44 Å.), is observed less often than [101], where the distance between the atoms is 6·68 Å.; the sliding planes were observed to be (110) and (100), the first being more frequent. H. N. A.

357. *The Effect of Drawing on the Crystal Structure of Tungsten Wires.* **L. P. Sieg.** (Iowa Acad. Sci., Proc. 28. pp. 95–97, 1921.)—The author finds that the coefficient of simple rigidity for a series of tungsten wires drawn down to different diameters from the same stock varies considerably. Sections of the wires were polished and etched with hot hydrogen dioxide and microphotographs obtained at a magnification of 100 diameters. It is claimed that they show a different crystal structure near the surface as compared with the interior, which accounts for the progressive changes in the elastic constants. S. L. S.

358. *Crystal Growth in Cadmium.* **M. Cook.** (Faraday Soc., Trans. 19. pp. 43–48; Disc., 48–51, July, 1923.)—The growth of crystals of cadmium when the metal is heated for long periods was studied. Cadmium, containing 0·07 % lead, and 0·08 % iron, was cast into rods and cooled slowly. Sections of the cast metal were examined, and showed small crystal grains. The metal was then annealed for 450 hours, 900 hours, and 1350 hours at 295° C. In this way very large crystals were obtained, showing that cast metal is able to show crystal growth without having been subjected to cold working. F. J. B.

359. *Source and Influence of Impurities in 80:20 Cupro-Nickel.* **C. Blazey.** (Dept. of Defence, Munitions Supply Board, [56 pp.], Nov., 1922.)—A complete survey of the source and influence of impurities in 80/20 cupro-nickel was made. The copper and nickel used in the preparation of the alloy contained only small amounts of impurities, a charge of 55 lbs. copper, 14 lbs. nickel, and 56 lbs. heavy scrap were melted in a Salamander crucible and cast. If new metal was employed the charge consisted of 100 lbs. copper, 25 lbs. nickel and 3 to 4 ozs. of cupro-manganese. The alloys were carefully analysed, and the effect of continuous remelting on the composition was determined, the melting being done in both new and old crucibles. The impurities increased with the number of remelts. The alteration of the physical properties due to presence of impurities and to the remelting was investigated. The strip rolled from the cast metal can be annealed, if duration of annealing is regulated. At high temperatures the safety range is very narrow and at 1000° C. deterioration is practically instantaneous. The deterioration is a function of carbon content, temperature of annealing, duration of annealing, and probably the presence of impurities. Absence of manganese coincides with very rapid deterioration. Curves are given showing the changes in composition due to remelting, etc., and tables of the results of impurities and heat-treatment on the physical properties. F. J. B.

360. *E.M.F. of Cells, Chemical Affinity, and Molecular Attraction.* **N. V. Karpen.** (Comptes Rendus, 177. pp. 449–451, Aug. 20, 1923.)—The author points out that the Nernst equation and the Helmholtz equation for e.m.f. are contradictory. He introduces a term in the former depending upon molecular attraction and reaches an expression which is more in accordance with the formula of Helmholtz. W. R. C.

361. *Electric Potential of Antimony-Lead Alloys.* **S. D. Muzaffar.** (Faraday Soc., Trans. 19. pp. 56–58; Disc., 58–59, July, 1923).—Measurements of the electric potential of the antimony-lead alloys, made by means of a quadrant electrometer against a calomel electrode in N-potassium hydroxide, N-lead nitrate, and acid potassium antimony tartrate solutions reveal an identity of potential up to 98 per cent. of antimony with that of lead. Hence these alloys form no chemical compound and no solid solution. T. H. P.

362. *Tungsten Wire for Hydrogen-Ion Determinations.* **J. R. Baylis.** (Indust. and Engin. Chem. 15. pp. 852–853, Aug., 1923.)—In order to indicate changes in hydrogen-ion concentration caused by chemicals used to purify the water supply of Baltimore, the tungsten wire of a 40-watt lamp is employed in conjunction with a calomel electrode. Over a range of values of Ph from 6·5 to 8·6 (determined colorimetrically) uniform results are obtained, the voltage increasing 0·09 volt for unit increase in value of Ph. The advantage of this method lies in the elimination of the use of hydrogen gas, and the author invites investigation of its possibilities under other conditions. B. W. C.

363. *The Quinhydrone Electrode as a Comparison Electrode.* **S. Veibel.** (Chem. Soc., J. 123. pp. 2203–2207, Sept., 1923.)—The work of Bülmann on quinhydrone electrodes [see Abstract 2349 (1922)], is extended with the object of producing a comparison electrode which will rapidly acquire its potential and preserve this for a considerable period. Experiments with solutions of weak organic acids, as used by Bülmann, show that the electrode may be prepared with great accuracy and rapidly attains its full potential value, but this is only preserved for a few hours. With 0·01N-hydrochloric acid + 0·09N-potassium chloride as electrolyte, measuring the potential directly against a hydrogen electrode, excellently reproducible results are obtained, and the durability is satisfactory for 48 hours. During this period the value of the potential is 0·7040 ± 0·0002 volt. In order to compare the values of the potential determined by a quinhydrone electrode with those of a 0·1N-calomel electrode, 0·2485 volt must be subtracted. Measurements made with a 0·1N-calomel electrode show that only by using fine-grained calomel can an electrode be obtained whose reproducibility is of the same order as the Bülmann quinhydrone electrode prepared as above. Even with 3·5N-calomel, the reproducibility does not surpass that of the Bülmann electrode. B. W. C.

364. *Electrolytic Preparation of Ortho-Amidophenol and Ortho-Nitrophenol.* **O. W. Brown** and **J. C. Warner.** (J. Phys. Chem. 27. pp. 455–465, May, 1923.)—At low current densities (1 to 2 amps. per sq. dcm.) the authors find that copper, zinc, zinc amalgam, and nickel are the most efficient as kathode materials in the reduction of ortho-nitrophenol to ortho-amidophenol. Lead gives the highest yields with a current density of 4 to 10 amps per sq. dcm. Amalgamation of a kathode decreases the efficiency. [See also Abstract 1703 (1923).] W. R. C.

Erratum. Abstract 172 (1924), line 1. *For* Q. Majorana *read* S. Magrini.